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| IDENTIFIERS | Electrical Wiring; *Power Line Technicians |

ABSTRACT

This module is the fourth in a series that is designed to help students achieve greater professional and personal success as power line technicians. Each module represents one or more complete units of instruction with components organized into one instructor and one student "package": the instructor's manual and the student workbook. The instructor's manual begins with a profile of training mastery that lists the competencies covered in the curriculum and provides space for recording information about the student's mastery of each objective. Other introductory matter includes information on use of the manual, recommendations for measuring student performance gains, and required criteria for a competency-based education program. The instructor's manual also contains one set per unit of these components: suggested activities, answers to assignment sheets, answers to test, transparency masters, and test. The student workbook contains one set per unit of most or all of these components: objective sheet, information sheets, assignment sheets, and job sheets. The four units in this module are as follows: (1) insulation, (2) substations, (3) grounds and jumpers (line equipment), and (4) voltage and current measuring. Most units are designed for use in more than one lesson or class period. (YLB)

ED 403 413

# Power Line Technician
# Second Edition

## Module D

## Instructor's Manual
## Student Workbook

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# Power Line Technician

Second Edition

## Module D

- Insulation
- Substations
- Grounds and Jumpers (Line Equipment)
- Voltage and Current Measuring

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CIMC

Instructor's Manual

97-012243

3

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Stillwater, OK 74074-4364
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TI1018

# POWER LINE TECHNICIAN
# PROFILE OF TRAINING MASTERY

Instructor _____ Date _____

Program _____

Grade _____ School _____

Name _____ Soc. Sec. No. _____

Address _____ Phone _____

In Case of Emergency, Contact _____

Address _____ Phone _____

Allergies/Disabilities that might require special accommodation for training (please specify) _____

**The above information can be used for school records and/or to ensure safety of students. This confidential information is not to be released to employers or the general public.**

Date of Enrollment ___-___-___ Total Class Hours _____ Total Hours Absent _____

Date of Withdrawal ___-___-___ Total On-the-Job Training Hours _____ Total Hours Tardy _____

Date of Completion ___-___-___ Total Lab Hours _____

## ON-THE-JOB TRAINING/WORK EXPERIENCE

Duration of Employment _____ Job Title _____ Supervisor's Name _____

Address of Employer _____ Phone _____

Duration of Employment _____ Job Title _____ Supervisor's Name _____

Address of Employer _____ Phone _____

## Use of This Document

This document can be used to record information about the student and skills mastered. This information is useful in documenting student progress during training and in providing information about the student's qualifications to potential employers and/or for entry into advanced training programs. Instructors using these materials are authorized to reproduce this document as required for use in their training programs.

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## SPECIFIC JOB COMPETENCIES

**Instructor: As each competency is mastered, place your initials and the date in the blank on the left. This will verify that the student can perform the skill with a minimum of supervision.**

### MODULE A

*Unit 1 – Orientation to REC*

Date/Initial

1. Match terms associated with REC orientation to the correct definitions.
2. State the reason for establishing the Rural Electrification Administration.
3. Discuss the importance of rural electric cooperatives.
4. Describe the benefits of rural electric cooperatives to rural America.
5. Select from a list the finance agencies which loan money to rural electric cooperatives.
6. List types of electric utilities.
7. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

*Unit 2 – Introduction to Power Line Technician's Training*

Date/Initial

1. List responsibilities of a line technician to the community.
2. Select from a list the responsibilities of a line technician to the employer.
3. Select from a list information that is shown on an organizational chart.
4. List departmental functions of a line department.
5. Select from a list topics taught in this course.
6. List benefits to students who complete the line technician's training course.
7. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

*Unit 3 – Job Advancement*

Date/Initial

1. Match terms associated with job advancement to the correct definitions.
2. List characteristics employers consider when making promotions.
3. Distinguish between good and poor work attitudes.
4. List steps that will help in job advancement.
5. Select from a list benefits of additional education and training.
6. Discuss activities that will better prepare a person for advancement.
7. Discuss reasons people do not succeed on the job.
8. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

*Unit 4 – General Safety*

Date/Initial

1. State the safety responsibilities of an REC employee.
2. List the steps of discipline for safety rule violations.
3. Select from a list items which are subject to safety rules.
4. State reasons for the importance of a safety policy.
5. Discuss OSHA regulations for first aid.
6. List the basic steps in first aid.
7. List steps of basic life support.
8. List first aid supplies.
9. List the practices for care of first aid supplies.
10. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

### MODULE B

*Unit 1 – Personal and Job Safety*

Date/Initial

1. Match terms associated with personal and job safety to the correct definitions.
2. Describe the procedures to follow for various types of rescue situations.
3. List components necessary for fire.
4. Match classes of fires to the correct description of each.
5. Match types of fire extinguisher to the class or classes of fire each is best suited to extinguish.
6. List general safety precautions to observe during rescue.
7. Discuss in a short paragraph driving skills needed by a line technician.
8. List some poor attitudes that may cause accidents.
9. Select from a list requirements of a skilled driver.
10. List steps of defensive driving.
11. Identify shapes of traffic signs.
12. Select from a list some general safety precautions to observe when operating equipment.
13. State OSHA/DOT regulations for inspection of equipment.
14. Select from a list the items which should be inspected daily on mechanical equipment.
15. List methods for maintaining a clean and orderly work area.
16. Explain how to lift heavy objects.
17. Describe in a short paragraph the importance of safety communications.
18. Select from a list those items of importance that should be reported to the supervisor.
19. Select from a list items related to safety that a line technician should know concerning location and voltage.
20. State factors which determine the maximum weight which can be lifted by equipment.
21. Determine maximum weight that can be lifted by equipment at various angles.
22. Complete a safety pledge form.
23. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

*Unit 2 – Communications*

Date/Initial

1. List types of communications necessary for an REC employee.
2. Select from a list those items of communication that are important between fellow workers.
3. List items of communication that are important between the worker and the supervisor.
4. Select from a list those items of communication that are important between the worker and the general public.
5. Identify hoist signals.
6. Identify winch line signals.
7. Identify hand signals used in boom operations.
8. Identify hand signals used when maneuvering vehicles.
9. Identify line work signals.
10. Select from a list the proper radio procedures.
11. State emergency radio procedure.
12. Select from a list the prohibited uses of the radio.
13. Match radio code signal numbers to the correct meanings.
14. List factors that are important when using cellular mobile telephones.
15. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

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***Student ratings on specific competencies evaluated during the course are available upon student's written request and/or by calling the instructor. Parent's or guardian's signature is necessary if student is under 18 years of age.***

Date/Initial

## *Unit 3 – Basic Electrical Theory*

1. Match terms associated with basic electrical theory to the correct definitions.
2. List uses of electricity.
3. Discuss the electron theory.
4. Distinguish between alternating and direct current.
5. Match types of magnets to the correct descriptions.
6. State the law of magnetic poles.
7. Describe magnetic force as it relates to production of electricity.
8. Select from a list characteristics of electromagnetic force.
9. Explain the generation of electricity using magnets.
10. Describe electromagnetic induction.
11. Identify types of circuits.
12. Identify conditions of circuits.
13. Name sources of alternating and direct current.
14. Identify divisions of an electrical system.
15. State the relationship among amperage, resistance, and voltage.
16. Solve problems using Ohm's law.
17. Calculate for an unknown voltage.
18. Calculate for an unknown amperage.
19. Calculate for an unknown resistance.
20. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

## *Unit 4 – Rope and Rigging*

1. Match terms associated with rope and rigging to the correct definitions.
2. Identify parts of a stationary block.
3. List kinds of rope used in line work.
4. Determine the tensile strength of various kinds and sizes of rope.
5. Determine the mechanical advantage of using block and tackle.
6. List uses of various types of rope gear.
7. Apply the formula necessary for the safe working load of various kinds and sizes of ropes when given the tensile strength and safety factory.
8. Identify various knots and hitches.
9. Match various knots and hitches with the correct uses.
10. Identify elements of knots, bends, and hitches.
11. List conditions that damage rope.
12. Calculate the mechanical advantage of using block and tackle.
13. Calculate working load of various ropes.
14. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

## *Unit 5 – Overhead Construction*

1. Match terms associated with overhead construction to the correct definitions.
2. Match materials commonly used in overhead construction to their specific uses.
3. Identify hand tools commonly used in overhead construction.
4. Match hand tools to their specific uses.
5. Identify overhead construction tools.
6. Match overhead construction tools to their specific uses.
7. List elements of overhead construction.
8. List equipment used in overhead construction.
9. Match equipment commonly used in overhead construction to their specific uses.
10. Select from a chart the correct depth to set poles of varying lengths.
11. List methods used to properly sag conductors.
12. Identify various types of connectors used in overhead construction.
13. Match types of construction to the correct descriptions.
14. List steps to properly install a pole key.
15. State correct procedure for installing a ground rod.
16. Arrange in order the steps to follow when framing a pole.
17. Identify various structures used in transmission line construction.
18. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

## *Unit 6 – Underground Distribution Construction*

1. Match terms associated with underground construction to the correct definitions.
2. Identify equipment used in underground construction.
3. Match various types of equipment to the specific uses.
4. List general requirements for underground construction.
5. Arrange in order the correct procedure for installing cable.
6. List precautions to observe when handling underground cable.
7. Select from a list methods of marking cable for identification.
8. List methods used to locate and identify a utility ditch.
9. Identify equipment used to terminate primary cable on a pole.
10. State the requirement for grounding underground equipment.
11. List hazards which may be encountered in underground construction.
12. List precautions to observe when splicing or terminating cable.
13. Select from a list the tools used in underground construction.
14. Make a proper splice in secondary cable.
15. Make a proper splice in primary cable.
16. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

## *Unit 7 – Personal Climbing Tools and Equipment*

1. Match terms associated to personal climbing tools and equipment to the correct definitions.
2. Identify personal climbing tools and equipment.
3. Match tools and equipment to the specific use.
4. List conditions to watch for when inspecting personal climbing tools and equipment.
5. Name types of maintenance for personal climbing tools and equipment.
6. List safety precautions to observe when climbing poles.
7. Select from a list the general procedure for climbing poles.
8. Name rules for safe and proper storage of personal tools and equipment.
9. Climb poles.
10. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

## *Unit 8 – Right-Of-Way*

1. Match terms associated with right-of-way clearing and control to the correct definitions.
2. List methods to maintain good public relations.
3. Identify tools used for right-of-way clearing and control.
4. State the purposes of right-of-way control.
5. Select from a list the safe working procedures for right-of-way clearing and control.
6. Select proper methods of tree trimming.
7. List steps to remove limb hanging over an energized conductor.
8. List steps to fell a tree.
9. State the specifications for clearing right-of-way for distribution line.
10. List types of clearing and chemical control for right-of-way.
11. Identify various trees that grow rapidly.
12. Identify poisonous vegetation.
13. Draw cuts needed to remove heavy limbs.
14. Draw procedure for removing limb hanging over energized conductor.
15. Draw procedure for felling a tree.
16. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____



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Date/Initial

*Unit 9 – Distribution Transformers*

1. Match terms associated with transformers to the correct definitions.
2. State the functions of a transformer.
3. Identify parts of a completely protected transformer.
4. Distinguish between additive and subtractive polarity as they relate to transformers.
5. List kinds of transformers.
6. Match types of transformers to the correct descriptions.
7. Classify types of transformers as oil-cooled or air-cooled.
8. Discuss technical considerations in protective grounding and jumpering.
9. List information found on a transformer nameplate.
10. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

**MODULE C**

Date/Initial

*Unit 1 – Poles*

1. Match terms associated with poles to the correct definitions.
2. List five types of preservatives used on poles.
3. Match the type of preservatives used on poles with their code letters.
4. Select from a table the classes of poles of varying lengths and circumferences.
5. Select from a list precautions to observe when handling poles.
6. Calculate the weights of various classes and lengths of commonly used poles using a table.
7. List methods used to set poles.
8. State the correct procedure for checking a pole before climbing.
9. Arrange in proper order the steps for pole inspection.
10. List methods used to support unsafe poles for climbing.
11. State the correct method for storing poles.
12. Select from a table the classes of poles of varying lengths and circumferences.
13. Calculate the weights of various classes and lengths of commonly used poles using a table.
14. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

*Unit 2 – Conductors*

1. Match terms associated with line conductors to the correct definitions.
2. List methods used to protect line conductor at supports.
3. Arrange in order the steps to follow when joining ACSR conductors.
4. Arrange in order the steps to follow when joining CWC conductors.
5. List classes of conductors.
6. List methods of reeling our conductor.
7. Identify various types of conductor ties.
8. Match types of conductors to their specific use.
9. State conductor clearance from ground, roofs and building walls for conductors carrying 750 volts or less.
10. State conductor clearance from ground for conductors carrying over 750 volts to 22,000 volts.
11. Match current-carrying capacities of various ACSR conductors to the correct conductor size.
12. Match current-carrying capacities of various copperweld copper conductors to the correct conductor size.
13. Install a preformed line tie on ACSR conductor on a de-energized circuit.
14. Install a top groove conductor tie on a de-energized copper conductor.
15. Install a preformed armor rod on ACSR conductor.
16. Join ACSR conductor.
17. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

*Unit 3 – Grounding and Connecting*

1. Match terms associated with grounds and connectors to the correct definitions.
2. State the purposes of grounding.
3. List methods of grounding.
4. Select from a list those elements necessary for good grounding.
5. Select from a list equipment which must be grounded.
6. State the correct procedure for installing temporary protective grounds.
7. Arrange in order the steps to follow when disconnecting and grounding at sectionalizer or recloser station.
8. Arrange in order the steps to follow when disconnecting and grounding at multiphase vertical corner.
9. State the procedure for installing temporary protective grounds at air-break switch on a transmission line.
10. List elements of a good connection.
11. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

*Unit 4 – Generators and Batteries*

1. Match terms associated with generators and batteries to the correct definitions.
2. List kinds of generating plants.
3. Match kinds of generators to the voltages produced by each.
4. Match kinds of generators to the specific uses.
5. Calculate the frequency (Hertz) of various generators.
6. List precautions to observe with the use of portable generators.
7. List types and kinds of voltage-producing cells.
8. Identify various circuits of connected batteries.
9. Select from a list precautions to observe when connecting batteries.
10. Arrange in order the steps to follow to connect lead-acid batteries when starting equipment.
11. Connect batteries in series and parallel.
12. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

*Unit 5 – Work Procedures (Nonenergized)*

1. Match terms associated with work procedures to the correct definitions.
2. Select from a list information found on a staking sheet.
3. Arrange in proper order the procedure for line construction.
4. List steps to follow when installing service wire.
5. State the procedure for connecting service wire.
6. Match the materials needed to construct primary and neutral assemblies using ACSR conductor 7.2kV construction.
7. List materials needed to install various pole ground assemblies.
8. List materials needed for various primary assemblies.
9. List materials needed to complete a work order.
10. Identify section numbers within a township.
11. Locate rural property in Oklahoma using legal descriptions.
12. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

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## MODULE D

### *Unit 1 – Insulation*

Date/Initial

1. Match terms commonly associated with insulators and insulation to their correct definitions.
2. List steps to follow when installing a pin type insulator.
3. Select from a list methods of insulating distribution voltages.
4. Select from a list methods of insulating various transmission voltages on wooden structures.
5. Match insulative materials to their specific uses.
6. Select from a list precautions to observe with insulators and insulation.
7. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

### *Unit 2 – Substations*

Date/Initial

1. Match terms commonly used with substations to the correct definitions.
2. State functions of a substation.
3. Identify components of a substation.
4. Match components of a substation to their specific use.
5. Arrange in order the steps for taking a substation out of service.
6. Select from a list precautions to observe with a substation.
7. Arrange in order the correct procedure for changing a substation oil circuit recloser.
8. State the correct procedure for bypassing a substation current transformer.
9. List indications in a substation that could cause an outage.
10. Match indications to problems which may occur in substations.
11. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

### *Unit 3 – Ground and Jumpers (Line Equipment)*

Date/Initial

1. Match terms commonly used with grounds and jumpers to the correct definitions.
2. Match types of jumpers to their specific use.
3. State requirements for various jumpers.
4. Select from a list the line equipment that is connected by jumpers.
5. Match types of jumpers to the correct installation methods.
6. State the requirements for safe grounding of line equipment.
7. Distinguish between proper and improper grounding methods.
8. Calculate current flow of faulted equipment which is improperly grounded.
9. Calculate voltage on improperly grounded faulted equipment.
10. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

### *Unit 4 – Voltage and Current Measuring*

Date/Initial

1. Match terms commonly used with voltage and current measurements to the correct definitions.
2. State the purposes of voltage and current measurements.
3. Identify equipment used for voltage and current measurements.
4. State the correct procedure for determining voltage drop of a service.
5. State the correct procedure for determining current demand on a primary circuit in a specific area.
6. State procedures for determining current demand on a transformer.
7. List steps to obtain primary line voltage drop.
8. Select from a list reasons for current measurements.
9. Match full load secondary current at 240 volts single phase to the kVA ratings of a transformer.
10. Select from a list precautions to observe when making voltage and current measurements.
11. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

## MODULE E

### *Unit 1 – Meters and Meter Application*

Date/Initial

1. Match terms commonly associated with metering to the correct definitions.
2. List general types of meters.
3. List types of meters by base construction.
4. List classes of meters and the current-carrying capacity of each.
5. Match meters to types of service.
6. Match meter to voltage ratings to types of service.
7. Match abbreviations and symbols used with metering circuit diagrams to the correct meanings.
8. List uses of current transformer metering.
9. List uses of self-contained meter connections.
10. Identify various self-contained meter connections.
11. Identify various transformer-rated meter connections.
12. Identify various transformer-rated meter connections for 600 volts or above.
13. State the procedure for selecting the correct meter.
14. List methods for determining voltage for wye and delta connected meters.
15. Match types of services to specific uses.
16. List types of meters which have multipliers.
17. Arrange in order the correct procedure for determining meter mutipliers.
18. List precautions to observe with metering.
19. Calculate the multiplier for a transformer-rated meter connected to a secondary line.
20. Calculate the multiplier for a transformer-rated meter connected to a primary line.
21. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

### *Unit 2 – System Knowledge*

Date/Initial

1. Match terms used with system knowledge to the correct definitions.
2. Define symbols used with overhead lines and equipment identification on system maps.
3. Define symbols used with underground lines and equipment identification on system maps.
4. Identify symbols used to locate cultural features on system maps.
5. List functions of automated equipment.
6. List precautions to observe with automated equipment.
7. Select from a list conditions associated with system terrain.
8. Identify symbols on a system map.
9. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____



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Date/Initial

### *Unit 3 – Transformer Connections and Banking*

1. Match terms commonly used with transformer connections and banking to the correct definitions.
2. Define characteristics of transformer construction.
3. Match symbols used with transformer voltage rating and connection diagrams to the correct meanings.
4. Discuss transformer polarities.
5. Discuss bushing locations in relationship to polarity on padmount transformers and compare to pole-type in regard to subtractive and additive.
6. Identify secondary coil connections for two- and three-wire service.
7. Identify single-transformer connections for three-wire service.
8. Identify two-transformer banks.
9. Define objectives an electrician must keep in mind when constructing three-phase banks.
10. List in order the step-by-step process for designing three-phase banks.
11. Describe phase relationships between the bushings in three-phase banks.
12. Identify types of primary and secondary connections for three-transformer banks.
13. List precautions to observe when selecting transformers to be banked or paralleled.
14. Identify secondary connections on a four-bushing transformer.
15. State the correct method of connecting wye and delta transformers to a primary line.
16. Arrange in order the steps to find a faulted transformer in a bank.
17. State the precautions to observe with transformer banks.
18. Connect transformer secondary coils in series and parallel.
19. Connect a wye-delta bank for three-phase four-wire 120/240-volt service.
20. Connect a wye-delta bank for three-phase three-wire 240-volt service.
21. Connect a wye-wye bank for three-phase four-wire 120/208-volt service.
22. Connect an open-wye open-delta bank for three-phase four-wire 120/240-volt service.
23. Connect an open-wye open-delta bank for three-phase three-wire 240-volt service.
24. Connect an open-delta open-delta bank for three-phase four-wire 120/240-volt service.
25. Connect two single-bushing transformers in parallel.
26. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

### *Unit 4 – Phasing*

1. Match the terms commonly associated with phasing to the correct definitions.
2. List elements of phasing.
3. State methods of determining phase rotation.
4. State the procedure for changing the direction of rotation of a three-phase motor.
5. Arrange in order the steps to follow when phasing circuits with a phasing meter.
6. Arrange in order the steps to follow to identify distribution phases.
7. Label substation distribution phases.
8. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

## MODULE F

Date/Initial

### *Unit 1 – Line Patrol*

1. Match types of line patrol to the specific purpose.
2. Select from a list items to observe when patrolling line.
3. Match items to the specific conditions to observe when patrolling a line.
4. List methods of line patrol.
5. Select from a list requirements of a line patroller.
6. List items to observe with line equipment.
7. Complete a line inspection form.
8. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

### *Unit 2 – Electrical Equipment*

1. Match terms used with electrical equipment to the correct definitions.
2. Match electrical equipment to the specific uses.
3. Arrange in order the steps to follow when connecting a voltage regulator to a three-phase line.
4. Arrange in order the steps to follow when placing a voltage regulator in service.
5. State the procedure for setting voltage regulator time delays.
6. State the procedure for taking a voltage regulator out of service.
7. List precautions to observe with voltage regulators.
8. List precautions to observe with capacitors.
9. Select from a list the benefits of capacitor application.
10. Name equipment that should be protected by lightning arresters.
11. Explain the method of coordinating reclosers with other reclosers.
12. List precautions to observe when installing sectionalizers.
13. Select from a list factors to consider when coordinating reclosers and fuses.
14. Connect voltage regulators to a three-phase line.
15. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

### *Unit 3 – Work Procedures (Hot Line, Basket, Hot Stick)*

1. List methods of hot line maintenance.
2. Select from a list OSHA requirements for aerial devices.
3. Select from a list rules to observe when working with aerial devices.
4. List elements of hot line maintenance.
5. State the procedure for hot line maintenance from an aerial device.
6. Arrange in order the steps to follow when changing a pole top insulator from a basket.
7. Match various hot line tools to their specific uses.
8. Install a wire tong saddle.
9. Change an insulator on an energized conductor using hot line tools on an A1 structure.
10. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

### *Unit 4 – Troubleshooting (Secondary)*

1. Match terms associated with troubleshooting to the correct definitions.
2. Match indications of malfunctions to the possible causes.
3. Arrange in order the correct procedure for troubleshooting electrical equipment.
4. List precautions to observe when troubleshooting electrical equipment.
5. Select from a list items of information to obtain while troubleshooting.
6. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

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## MODULE G

**Date/Initial**

*Unit 1 – Troubleshooting (Primary Line)*

_____ 1. Match troubleshooting problems to possible causes.
_____ 2. Arrange in order the troubleshooting procedures to follow for various problems.
_____ 3. List precautions to observe when troubleshooting primary lines.
_____ 4. Arrange in order the steps for troubleshooting a primary line outage.
_____ 5. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

**Date/Initial**

*Unit 2 – System Knowledge*

_____ 1. List problems associated with line switching.
_____ 2. Arrange in order the steps to follow when switching line.
_____ 3. List factors involved in line switching.
_____ 4. Select from a list precautions to observe with line voltage regulators on a switched line.
_____ 5. List precautions to observe when opening a line switch.
_____ 6. Select from a list areas and locations of importance to the line technician.
_____ 7. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

**Date/Initial**

*Unit 3 – Conversions*

_____ 1. List types of conversions.
_____ 2. Arrange in order the steps to convert a primary line to a higher voltage.
_____ 3. Arrange in order the steps to change a substation feed area to a higher voltage.
_____ 4. Explain benefits of converting to a higher voltage.
_____ 5. Select from a list precautions to observe with autotransformers.
_____ 6. Arrange in order the steps to convert a single-phase line to V-phase.
_____ 7. Arrange in order the steps to convert a single-phase line to three-phase.
_____ 8. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

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# Power Line Technician: Module D

## Instructor's Manual

**Upfront**

**Suggested Activities**

**Answers to Assignment Sheets**

**Answers to Test**

**Transparency Masters**

**Test**

Developed by the
Curriculum and Instructional Materials Center
Oklahoma Department of Vocational and Technical Education

97-012243

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Curriculum and Instructional Materials Center

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One set per unit of the following components:

- Suggested Activities
- Answers to Assignment Sheets
- Answers to Test
- Transparency Masters
- Test

### Student Workbook

One set per unit of Objective Sheets, Information Sheets, Assignment Sheets, and Job Sheets for each of the units in this module:

MODULE A

1. Orientation to REC
2. Introduction to Power Line Technician's Training
3. Job Advancement
4. General Safety

MODULE B

1. Personal and Job Safety
2. Communications
3. Basic Electrical Theory
4. Rope and Rigging
5. Overhead Construction
6. Underground Distribution Construction
7. Personal Climbing Tools and Equipment
8. Right-of-Way
9. Distribution Transformers

MODULE C

1. Poles
2. Conductors
3. Grounding and Connecting
4. Generators and Batteries

5. Work Procedures (Nonenergized)

MODULE D

1. Insulation
2. Substations
3. Grounds and Jumpers (Line Equipment)
4. Voltage and Current Measuring

MODULE E

1. Meters and Meter Application
2. System Knowledge
3. Transformer Connections and Banking
4. Phasing

MODULE F

1. Line Patrol
2. Electrical Equipment
3. Work Procedures (Hot Line, Basket, Hot Stick)
4. Troubleshooting (Secondary)

MODULE G

1. Troubleshooting (Primary Line)
2. System Knowledge (Phase II)
3. Conversions

## FOREWORD

The *Power Line Technician* series is designed to help students achieve greater professional and personal success. As a tool for building a rewarding career, this series will help students develop their professional competence. In addition, the series provides a foundation for career advancement. The *Power Line Technician* series consists of seven modules which address specific skill areas. Each module represents one or more complete units of instruction with components organized into one student and one instructor "package": the *Student Workbook*, and the *Instructor's Manual*. We believe the format and packaging will facilitate both the delivery and mastery of the identified competencies.

We hope that this series will enhance instruction and contribute to rewarding learning experiences for all students.

Roy Peters, Jr.
State Director
Oklahoma Department of
Vocational and Technical Education

Ivan Armstrong
State Supervisor
Trade and Industrial Education

## ACKNOWLEDGMENTS

The Curriculum and Instructional Materials Center (CIMC) extends its appreciation to the individuals who played key roles in the development of this publication. Such a comprehensive effort requires contributions from many people. We sincerely appreciate the support necessary to complete this project.

Design: Special thanks are extended to the representatives from industry, teaching, and vocational education who participated as members of the curriculum advisory committees for the *Power Line Technician* series. We also thank the administrators, supervisors, and others who supported their participation. Significant contributions were made during the revision process by participants from ABB Power T&D Company Inc., the Association of Missouri Electric Cooperatives, the Central Rural Electric Cooperative (Stillwater, Oklahoma) and the City of Stillwater.

Development: The modules in this series were edited by Craig Maile and Dr. Lois Sharpton. Individual modules were formatted by Vonda Gile. Brenna Tillman, Publications Supervisor in the CIMC, assisted in adapting the packaging.

Production: The close cooperation and dedication of professionals at the Oklahoma Department of Vocational and Technical Education were instrumental in producing the *Power Line Technician* series. Unit and cover artwork were designed by the Art Department, under the direction of Bob Davis, Art Manager. This series could not have been printed without the expertise and commitment of the Printing Plant Staff, under the direction of Danny Darrow. Delivering the final product was accomplished through the excellence of the CIMC Customer Service staff and the staff of the CIMC Warehouse, under the direction of Darrell Stiles.

Support: A number of people at the CIMC helped to make this series possible. Terri Tomson efficiently handled the development contracts, committee meetings, and correspondence relating to this series. This project also received generous support from John Friedemann, CIMC Team Leader, and Dr. Lynna Ausburn; Development Coordinator.

Project Management: Dr. Marilyn Troupe and Craig Maile

## USE OF THIS PUBLICATION

Each unit of instruction is based on the performance needed for successful employment in an occupational area. A complete unit will contain most or all of the following components: Objective Sheet, Suggested Activities, Information Sheet, Assignment Sheet, Job Sheet, Test, Answers to Assignment Sheets, Answers to Test, and Transparency Masters. These components are organized within two packages, as follows:

*Instructor's Manual*

- Upfront pages
- One set per unit of:
  - Suggested Activities
  - Answers to Assignment Sheets
  - Answers to Test
  - Transparency Masters
  - Test

*Student Workbook*

- Objective Sheets
- Information Sheets
- Assignment Sheets
- Job Sheets

Instructor's materials include the *Instructor's Manual* and the *Student Workbook*.

Unit components are tied to measurable and observable learning outcomes. Instructors are encouraged to supplement unit components with other resources to make units as responsive to local conditions and student needs as possible.

Most units of instruction are designed for use in more than one lesson or class period. Instructors should determine the following for each unit:

- amount of material that can be covered in each class period;
- skills that must be demonstrated;
- supplies and equipment needed;
- amount of class time needed for demonstrations;
- amount of class time needed for student practice;
- supplementary materials to be ordered; and
- resource persons who must be contacted.

**Objective Sheet** (Student Workbook)

The Objective Sheet summarizes each unit for the student and the instructor. The Objective Sheet includes the following sections:

> **Unit Objective** – The Unit Objective states the overall goal of the unit. It identifies what the student will be able to do after successfully completing the unit, as well as the standards used to measure student performance.
>
> **Specific Objectives** – The Specific Objectives outline the teaching sequence of the competencies required to reach the Unit Objective.

The Specific Objectives on the Objective Sheet should be emphasized to all students at the start of each unit and throughout the teaching/learning process. This will help answer student questions about performance requirements for each unit. Specific Objectives can also assist instructors in determining teaching strategies and instructional methods. Instructors should prepare for each unit by deciding how each objective could best be taught.

Instructors should modify, delete, or add objectives to meet the needs of students and the community. When objectives are added, the instructor should remember to provide the needed information, Assignment and/or Job Sheets, and criterion-referenced test items to cover the new objectives.

**Information Sheet** (Student Workbook)

The Information Sheet provides the "must know" content essential for meeting the cognitive objectives in the unit. The Information Sheet may include clarifying NOTES and EXAMPLES, as needed. Students should read the Information Sheet for each unit before it is discussed in class.

**Assignment Sheets** (Student Workbook)

The Assignment Sheets address the learning levels at or above the application level of Bloom's taxonomy. They allow students to perform non-psychomotor activities related to occupational tasks. Assignment Sheets also provide students with an opportunity to use higher-order thinking skills, such as problem-solving, synthesizing, analyzing, and evaluating. In addition, they may provide opportunities for cooperative learning and more detailed oral/written communication activities.

**Job Sheets** (Student Workbook)

Job Sheets give students step-by-step procedures for performing manipulative or psychomotor occupational tasks or jobs. The Job Sheet also facilitates the instructor's evaluation of each student's performance. Both the process and the end-product are evaluated. Diagrams, illustrations, and photographs are included, as needed, to assist students in completing the job.

The instructor should demonstrate the procedure outlined in each Job Sheet. Instructors may also have to localize specific procedures.

**Suggested Activities** (Instructor's Manual)

Instructors should study the Suggested Activities before introducing the unit, allowing enough time to obtain supplemental materials, prepare audiovisual materials, and contact outside resource persons. Specific tasks of the instructor will vary with each unit.

**Answers to Assignment Sheets and Answers to Test** (Instructor's Manual)

These components list the answers to all of the Assignment Sheets and the Test questions.

**Transparency Masters** (Instructor's Manual)

Transparency Masters are provided so that instructors can make transparencies to accompany specific units. Transparencies allow students to *see* as well as hear the information being presented, thus reinforcing the learning process. They also direct attention to the topic under discussion. Transparencies should be left on the screen only when the related topics are under discussion.

**Test** (Instructor's Manual)

The Test provides criterion-referenced evaluation of the Specific Objectives from the Information Sheet (Assignment Sheet and Job Sheet objectives are not evaluated by the Test). If instructors have added, deleted, or modified any objectives, appropriate changes should be made to the Test as well.

The Test serves as both a pretest and a posttest. In order to measure and document student competency gains as required by the latest Carl Perkins regulations, and as outlined in the Oklahoma-developed system of standards and measures, it is *essential* that the same test be used as a pretest and as a posttest. If instructors choose to use tests other than the unit Test, they should make sure that the same instrument is used for each activity – pre- and posttest.

A detailed explanation of the Oklahoma plan for standards and measures and the Carl Perkins requirements is included in the CIMC publication *Measuring Learning & Competency Gains: The Pretest/Posttest Approach*. This booklet – and accompanying software to assist in calculating and recording student gains – are available to Oklahoma instructors through their school's vocational testing liaison.

**Profile of Training Mastery**

The Profile of Training Mastery documents student performance. Each profile lists the competencies covered in the curriculum, and provides space for recording information about the student and the student's mastery of each objective. Space is also provided for recording pre- and posttest scores, modified gains, and instructor comments. A blank Profile of Training Mastery is available for this series. It may be reproduced for each student.

**Page Numbering**

Each Module is identified with a letter (A - G). Each unit and page has a number, shown in Arabic numerals. For example, the page number for Module A, Unit 2, page 3 of the *Student Workbook* would appear as follows:

PLT A - 2 - 3

**Methods of Disseminating Material**

For best results, provide each student with a copy of the Student Workbook. Students should be allowed to keep their Workbooks at the end of the course or training program.

**Teaching Methods**

Keeping students motivated is a challenge. Supplement each unit with current information, personal experiences, and other information. In a group setting, prepare for each unit by determining the best way to teach each objective, and allow for student input. For individualized instruction, provide opportunities for the student to become involved in planning and being responsible for his or her own education.

## MEASURING STUDENT PERFORMANCE GAINS

Each CIMC unit contains only a single unit Test. This test should be used as **both** pretest and posttest by giving it once before students start a unit and again when they have completed the unit.

The reason for using a single instrument as both pretest and posttest is so that direct comparison of each student's competencies before and after instruction can be made accurately. This comparison enables precise calculation, documentation, and evaluation of student **performance gains**.

Accurate performance gains analysis is an important requirement of the new Carl Perkins legislation for vocational education. Teachers can make an important contribution to the performance accountability mandated by the new federal legislation by carrying out accurate performance gains analysis for their students, and making this data available to students, parents, and administrators.

This analysis is easy to do and requires only simple calculations and record keeping. Detailed information regarding performance gains analysis is contained in the CIMC publication, *Measuring Learning & Competency Gains: The Pretest/Posttest Approach.* In addition, the CIMC has developed a computer program, CARL, which will perform all necessary calculations and will print out a record form of all information required for gain score analysis. Copies of CARL and the publication are available through your local testing liaison (in Oklahoma), or from the CIMC at 1-800-654-4502.

**REQUIRED CRITERIA FOR A COMPETENCY-BASED EDUCATION PROGRAM**

| **Criterion** | **Discussion** | **CIMC component meeting criterion** |
|---|---|---|
| **1. Instruction is based on clearly-stated learning objectives that are: a) observable and measurable, and b) communicated in writing to students before instruction begins.** | Learning objectives drive CBE. Objectives are the "competencies" that learners must achieve. Each objective must clearly state what *learners* must *do* to demonstrate acquired skill or knowledge. Verbs in learning objectives are active and precise, stating the exact performance expected of learners. The objectives should also specify the standard or level of performance required. Objectives can be at any level of Bloom's Taxonomy and can include the cognitive, psychomotor, and affective domains. Higher-order cognitive skills should be included. | Objective Sheet |
| **2. Instruction is aligned with the stated learning objectives.** | In CBE, the objectives specify what is taught. "Content" should relate to one or more objectives. The curriculum should cover all objectives with relevant information. | Information Sheet |
| **3. There is a student evaluation system that is: a) criterion-referenced, and b) aligned to the learning objectives and the curriculum.** | In CBE, the aim is to bring the performance of *all* learners up to a pre-defined standards and competencies. Learners work on each competency until they achieve "mastery"; the evaluation system should test and record this mastery. Learners can restudy and retest as often as needed. Specific remediation activities should also be available to learners when needed. The evaluation system focuses on what each student has achieved, not on what the instructor has "taught." The "constant" in CBE is student performance; the "variables" are time and resources. (This differs from traditional systems where learners get one chance at mastery; some succeed and some fail. In such systems, time and resources are constant and student achievement is variable.)<br><br>If an evaluation is criterion-referenced, successful learner performance is defined by (or *referenced* to) mastery of pre-set objectives and standards (or *criteria*): there must be a careful match (or *alignment*) between what the student should master (objectives), what is taught (curriculum), and what is tested. Objectives, curriculum, and evaluation system must all match. | Test and Job Sheet |

| Criterion | Discussion | CIMC component meeting criterion |
|---|---|---|
| **4. There is an observable management system of cognitive skill practice that provides for, promotes, and documents mastery learning.** | For both cognitive and psychomotor skills, a CBE program must have a system of maintaining records of which skills and activities each learner has completed, which ones are in progress, and which ones have not yet been completed. Completion means "mastery"; no skill is completed until the learner has achieved the mastery level.<br><br>The record system should promote feedback on student skill attainment to *both* instructor and learners, provide for remediation as needed, and encourage reevaluation of learner performance until mastery is achieved. Appropriate remediation strategies often should consider learning styles and other individual differences among learners.<br><br>Learners should work on skills and activities until they achieve mastery. They should not be "passed on" without mastery. While learners may move ahead and work on other skills (i.e those for which all prerequisite skills have been mastered or those without prerequisites), work should also continue on the skills still requiring mastery. Students should not attempt higher-order skills until all prerequisite skills are mastered. | Assignment Sheet |
| **5. There is an observable management system of psychomotor skill practice that provides for, promotes, and documents mastery learning.** | | Job Sheet |
| **6. Skill mastery records are maintained for each learner, and learners have access to and make use of these records to monitor their skill acquisition.** | Records should clearly indicate the skills each learner has mastered. One such record should profile or list the competencies that have been mastered and those to be mastered. Other performance indicators can be added and kept in a portfolio for each learner. Learners should have ready access to their portfolios to monitor their own progress in skill mastery and competency attainment. | Profile of Training Mastery |

## CORRECTIONS AND SUGGESTIONS

The Curriculum and Instructional Materials Center (CIMC) wants to provide vocational instructors and students with accurate and effective materials. Although the CIMC strives to maintain the highest standards of development and production, oversights sometimes do occur. If you find any errors in this or other CIMC publications, or have suggestions for improving their usefulness in vocational programs, please notify the CIMC staff. To do this, please identify the page(s) affected and write any comments to clarify the error or suggestion. Use the spaces below. Then, simply fold (bottom of page *upward*, top *downward*), secure, and mail.

This information will be used to correct the publication before the materials are reprinted. To ensure that the material is updated on a timely basis, notify the CIMC of necessary corrections as soon as possible after discovering the error.

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Page: Comment:

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PLACE
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VOCATIONAL AND TECHNICAL EDUCATION/CIMC
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STILLWATER OK 74074-4364

INSULATION
UNIT 1

SUGGESTED ACTIVITIES

1. Suggested activities for instructor:

   - Provide student with objective sheet.
   - Provide student with information sheet.
   - Make transparencies.
   - Discuss unit and specific objectives.
   - Discuss information sheet.
   - Show student films, charts, and other supplemental information on insulation.
   - Give test.

2. Unit references:

   - Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook*. 8th ed. New York: McGraw-Hill Book Co., 1992.
   - *Power Line Technician*. Stillwater, OK: Oklahoma Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1978.

# INSULATION
# UNIT 1

## ANSWERS TO TEST

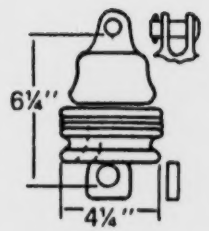
1. a. 4 i. 13
   b. 10 j. 7
   c. 3 k. 12
   d. 14 l. 5
   e. 11 m. 1
   f. 9 n. 6
   g. 8 o. 16
   h. 2 p. 15
2. a. Check for cracks or chips
   b. Screw insulator onto pin
   c. Align top groove with conductor
   d. Install tie
3. a. 2, 3, 4
   b. 2, 3
4 a. 2
   b. 2
   c. 2
   d. 2
   e. 1
   f. 2

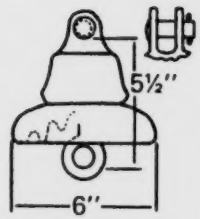
## ANSWERS TO TEST

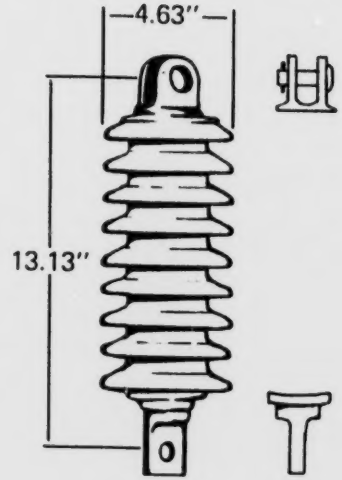
5. a. 7 e. 4
   b. 5 f. 2
   c. 1 g. 3
   d. 6

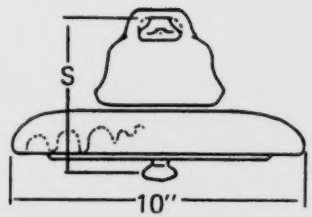
6. a, b, c, d, e, f, h, i

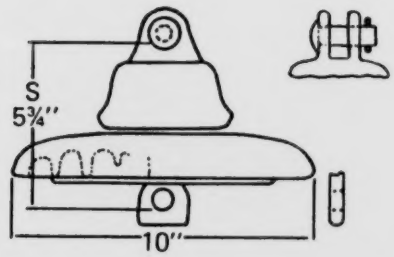
# Suspension Insulators



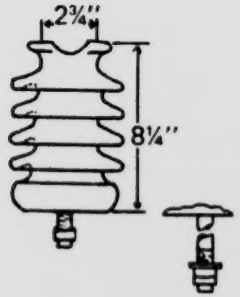



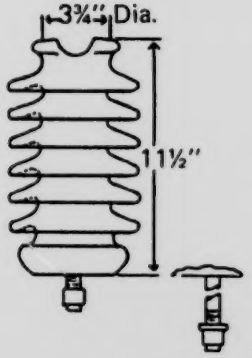




May be photocopied for student use.

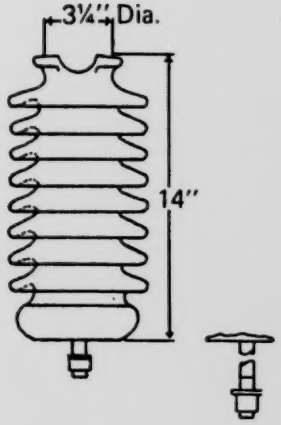
# Tie Top Post Insulators



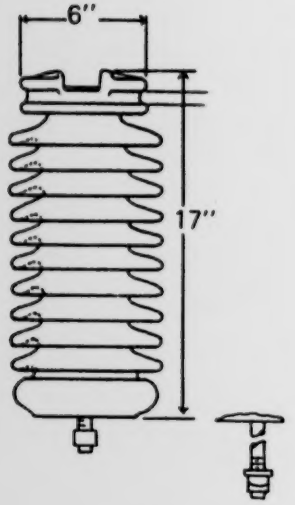

**14.4 kV**




**34.5 kV**




**45 kV**




**69 kV**

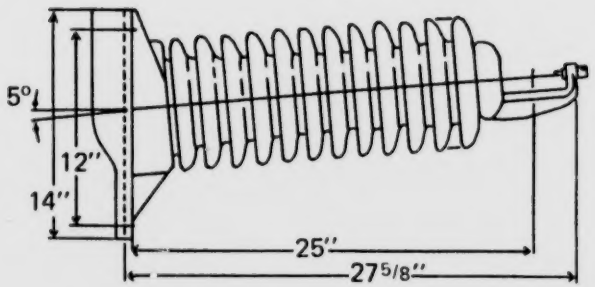
May be photocopied for student use.

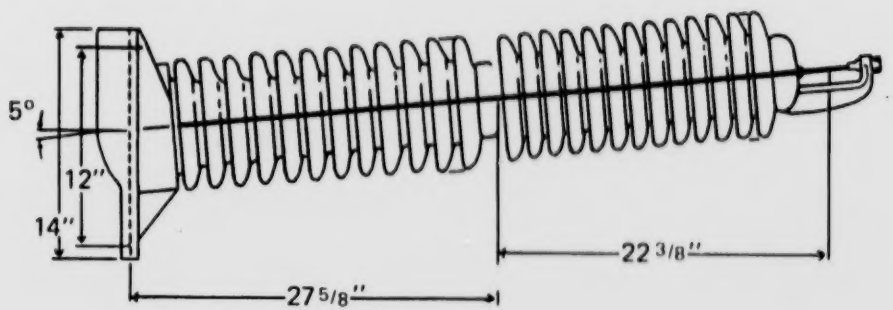
TM 2

PLT D - 1 - 7

# Side Post Insulators

**Side Post Insulator**
**Clamp Top 69 kV**

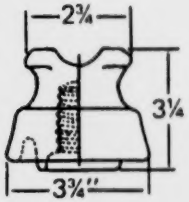


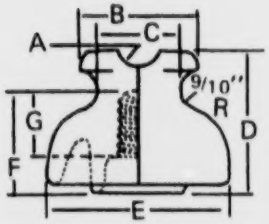




**Side Post Insulator, Clamp Top 138 kV**

May be photocopied for student use.

# Pin Insulator

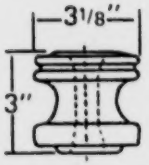


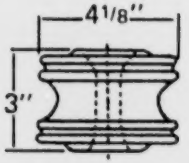



Dimensions in inches

| A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| 9/16 | 3 1/8 | 2 1/4 | 3 13/16 | 4 7/8 | 2 3/4 | 1 3/4 |
| 1 | 3 3/4 | 2 3/4 | 4 1/4 | 4 7/8 | 2 7/8 | 1 7/8 |
| 9/16 | 3 1/2 | 2 7/8 | 4 1/2 | 5 5/8 | 3 1/4 | 2 |
| 1 | 4 | 2 7/8 | 4 9/16 | 5 5/8 | 2 13/16 | 2 |
| 9/16 | 4 | 2 7/8 | 5 | 7 1/8 | 3 5/16 | 2 |
| 1 | 4 1/4 | 2 7/8 | 5 1/8 | 7 1/8 | 3 5/16 | 2 |

## Secondary Spool Insulator




May be photocopied for student use.

# INSULATION
# UNIT 1

## TEST

NAME _____ SCORE _____

1. Match the terms commonly associated with insulators and insulation on the right to the correct definitions. (Definitions are continued on the following page.)

_____a. Arc between an energized conductor and hardware over an insulator

_____b. Insulator which can be joined to others to form a string of insulators

_____c. Insulator which mounts by means of a stud bolt in the base of the insulator

_____d. Insulator which bolts to the side of a structure in a horizontal position

_____e. Insulator which mounts on a steel pole top or crossarm pin

_____f. Insulator which mounts on an upset bolt, with a clevis, or on a rack

_____g. Material used to make insulators; made from kaolin, quartz, and feldspar

_____h. High strength, rigid insulative material

_____i. Tough, flexible insulation whose atoms are chemically bonded

_____j. Solid, tough, flexible insulation

_____k. Thermosetting, rubber-like insulation

_____l. Flexible, hi-dialectric insulation

_____m. Smallest element of a substance which retains its identity in a mass

_____n. Gas generated from an electric arc which will destroy natural rubber

1. Molecule
2. Fiberglass
3. Post insulator
4. Flashover
5. Natural rubber
6. Ozone
7. Low density, high molecular weight polyethylene
8. Porcelain
9. Spool insulator
10. Suspension insulator
11. Pin insulator
12. Ethylene propylene
13. Cross-linked polyethylene
14. Side post insulator
15. Basic insulation level
16. Hi-dialectric

*May be photocopied for student use.*

TEST

_____o. Any substance with high resistance to current flow

_____p. Level at which insulation can withstand a voltage impulse without breaking down

2. List four steps to follow when installing a pin type insulator.

a. _____

b. _____

c. _____

d. _____

3. Select from a list the correct methods of insulating distribution voltages by placing an "X" in front of the correct methods.

a. 14,400-volt dead ends and angles

_____1) Four 4 1/4" suspension insulators

_____2) Three 6" suspension insulators

_____3) Two 10" suspension insulators

_____4) Three 4 1/4" suspension insulators

b. 7,200-volt dead ends and angles

_____1) Three 4 1/4" suspension insulators

_____2) Two 6" suspension insulators

_____3) Two 4 1/4" suspension insulators

4. Select from a list methods of insulating various transmission voltages on wooden structures by placing an "X" in front of the correct methods.

a. 138,000-volt vertical suspension

_____1) Eight 10" suspension insulators

_____2) Nine 10" suspension insulators

*May be photocopied for student use.*

TEST

b. 138,000-volt horizontal angles

_____1) Nine 10" suspension insulators

_____2) Ten 10" suspension insulators

c. 138,000-volt dead ends

_____1) Ten 10" suspension insulators

_____2) Eleven 10" suspension insulators

d. 69,000-volt vertical suspension

_____1) Six 10" suspension insulators

_____2) Four 10" suspension insulators

e. 69,000-volt horizontal angles

_____1) Six 10" suspension insulators

_____2) Five 10" suspension insulators

f. 69,000-volt dead ends

_____1) Five 10" suspension insulators

_____2) Six 10" suspension insulators

5. Match the insulative materials on the right to their specific uses.

_____a. Used in the manufacture of pin, suspension, and bushing insulators

_____b. Used in the manufacture of pin and suspension insulators

_____c. Used in the manufacture of hot line tools, cover-up material, and hot line equipment

_____d. Used as a covering on overhead and underground low voltage cable

_____e. Used for cable insulation up to 35 kV

_____f. Used for cable insulation above and below 35 kV

_____g. Used in the manufacture of rubber gloves, rubber sleeves, and cover-up materials

1. Fiberglass
2. HMPE
3. Natural rubber
4. EP
5. Tempered glass
6. XLPE
7. Porcelain

*May be photocopied for student use.*

TEST

6. Select from a list precautions to observe with insulators and insulation by placing an "X" in front of the correct precautions.

_____a. Keep rubber goods away from petroleum products

_____b. Store rubber goods away from electrical equipment

_____c. Clean rubber goods often with mild detergent

_____d. Check protective and cover-up material daily for cracks, cuts, or deterioration

_____e. Do not fold rubber protective equipment

_____f. Wear gloves when handling porcelain or glass insulators

_____g. Clean insulators daily with mild detergent

_____h. Transport insulators in cartons to avoid breakage

_____i. Store rubber goods away from heat and sunlight

*May be photocopied for student use.*

# SUBSTATIONS
# UNIT 2

## SUGGESTED ACTIVITIES

1. Suggested activities for instructor:

   - Provide student with objective sheet.
   - Provide student with information sheet.
   - Discuss unit and specific objectives.
   - Discuss information sheet.
   - Give test.

2. Unit references:

   - *Power Line Technician.* Stillwater, OK: Oklahoma Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1978.

SUBSTATIONS
UNIT 2

ANSWERS TO TEST

1. a. 4 f. 3
   b. 5 g. 8
   c. 1 h. 7
   d. 2 i. 9
   e. 6 j. 10

2. (NOTE: Any four of the following are acceptable.)
   a. Provide a distribution point as close as possible to a load center
   b. Provide a metering point for distribution power
   c. Provide protection for the power transformer and the transmission line
   d. Transform transmission voltage to distribution voltage
   e. Regulate voltage

3. a. Voltage regulator panel
   b. Air-break switch (three-phase)
   c. Transmission line
   d. Lightning arrester (station type)
   e. Transformer-regulator
   f. Bus bars with disconnect switches
   g. Air-break switch operating handle
   h. Substation ground
   i. Instantaneous ammeter
   j. Demand meter with timed and printed tape
   k. Kilowatt-hour meters

## ANSWERS TO TEST

l. Potential transformer

m. Current transformer

n. Metering cabinet

o. Lightning arrester

p. Bypass switch

q. Disconnect switches

r. Oil circuit recloser

s. Transformer-regulator indicator gauges

4.

| | | | | | |
|---|---|---|---|---|---|
| a. | 4 | g. | 9 | m. | 16 |
| b. | 7 | h. | 14 | n. | 1 |
| c. | 2 | i. | 15 | o. | 10 |
| d. | 8 | j. | 11 | p. | 5 |
| e. | 12 | k. | 6 | | |
| f. | 3 | l. | 13 | | |

5.

| | | | |
|---|---|---|---|
| a. | 4 | d. | 2 |
| b. | 1 | e. | 3 |
| c. | 6 | f. | 5 |

6. b, c, d, e, g, h

7.

| | | | | | |
|---|---|---|---|---|---|
| a. | 15 | f. | 12 | k. | 14 |
| b. | 6 | g. | 8 | l. | 5 |
| c. | 9 | h. | 11 | m. | 7 |
| d. | 2 | i. | 4 | n. | 13 |
| e. | 3 | j. | 10 | o. | 1 |

ANSWERS TO TEST

8. a. Take the substation out of service
   b. Ground the circuit
   c. Remove jumpers from current transformer
   d. Remove current transformer
   e. Connect current transformer jumpers together
   f. Put substation back in service

9. (NOTE: Any three of the following answers are acceptable.)
   a. Arcing sound
   b. Bird's nest in the structure
   c. Excessive heat in the power transformer
   d. Excessive noise in transformer, regulator, or metering equipment

10. a. 4
    b. 3
    c. 1
    d. 2

SUBSTATIONS
UNIT 2

TEST

NAME _____ SCORE _____

1. Match the terms commonly used with substations on the right to the correct definitions.

_____a. Fuse which protects the transmission line from a short circuit in a substation

_____b. Buried metal mat or conductor under and around a substation

_____c. Lightning arrester designed to protect a substation transformer from high voltage surges

_____d. Switch designed to open a circuit which is not under heavy load

_____e. Switch designed to change current flow around a piece of equipment

_____f. Heavy conductor made of copper or aluminum wire or bar which distributes current in a substation

_____g. Section of a substation which contains one secondary three-phase circuit

_____h. Switch which protects the substation transformer from short circuits on distribution lines

_____i. Switch used on heavy loads, usually above 200 amperes

_____j. Includes, but is not limited to, gloves, gowns, laboratory coats, face shields or masks and eye protection, and mouthpieces, resuscitation bags, pocket masks, and other ventilation devices

1. Station arrester
2. Air-break switch
3. Bus
4. High side fuse
5. Grounding grid
6. Bypass switch
7. Oil circuit recloser
8. Bay
9. Vacuum recloser
10. Personal protective equipment

*May be photocopied for student use.*

TEST

2. State four of the functions of a substation.

a. _____

_____

b. _____

_____

c. _____

_____

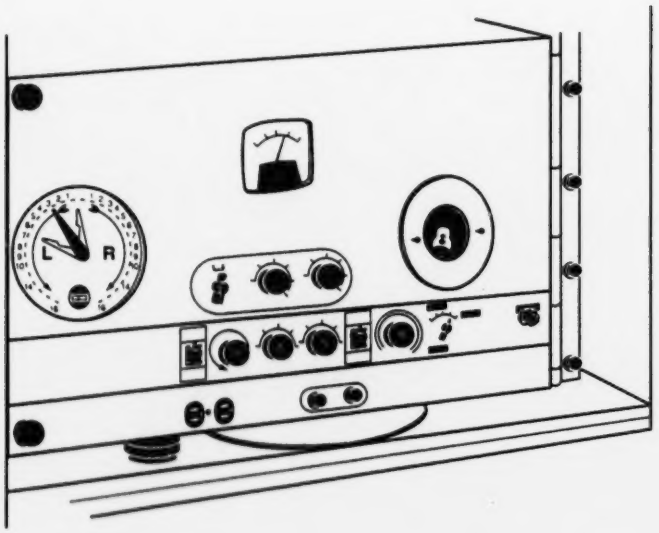
d. _____

_____

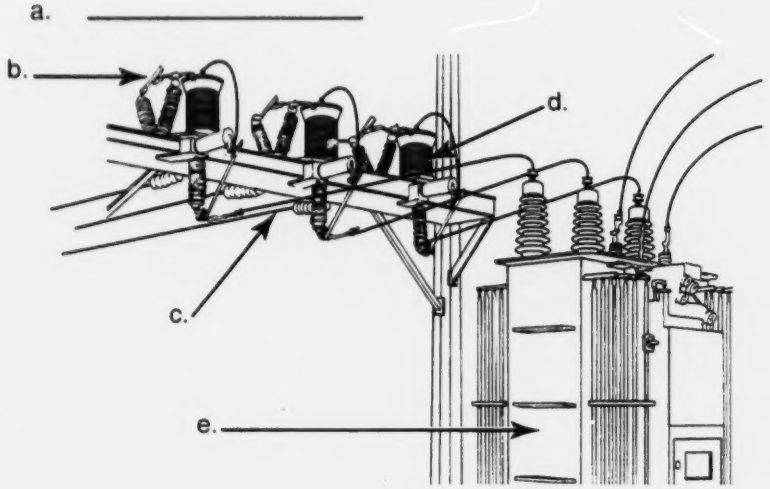
*May be photocopied for student use.*

TEST

3. Identify the following components of a substation.




a. _____




b. _____

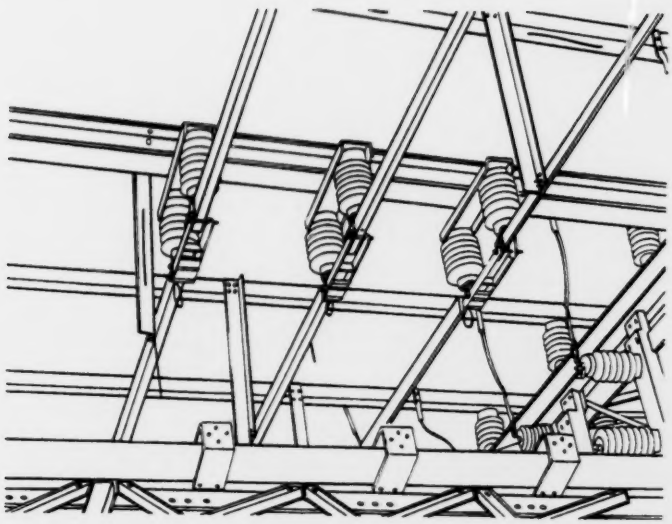
c. _____

d. _____

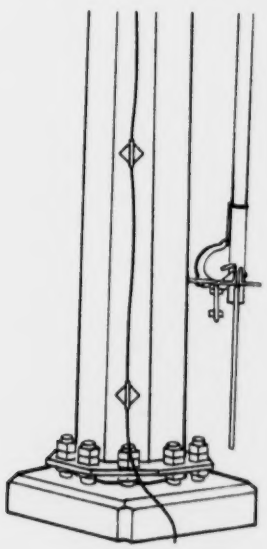
e. _____

*May be photocopied for student use.*

TEST



f. _____

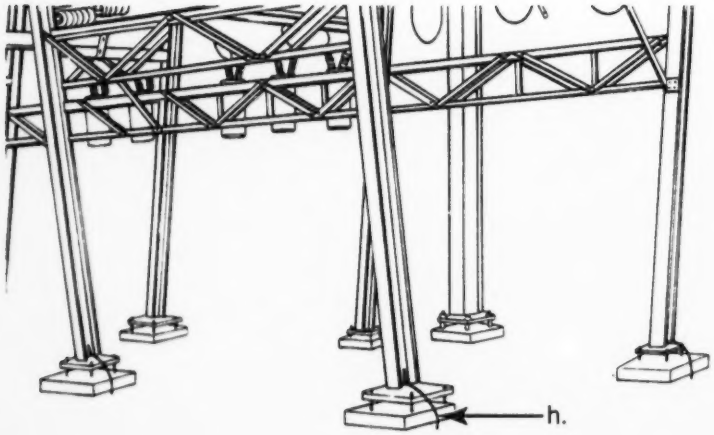


g. _____

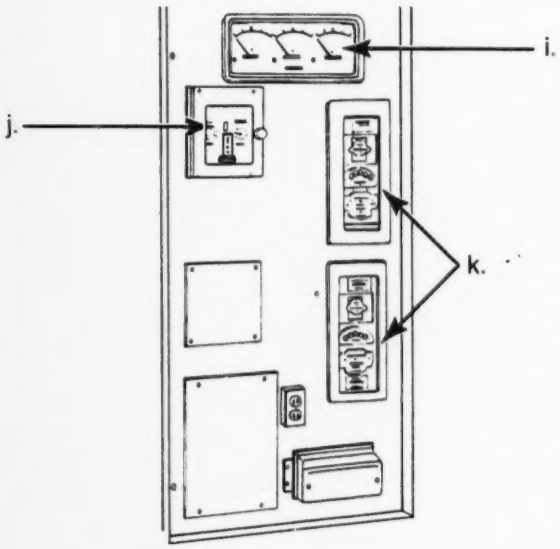


*May be photocopied for student use.*

TEST




h. _____




i. _____

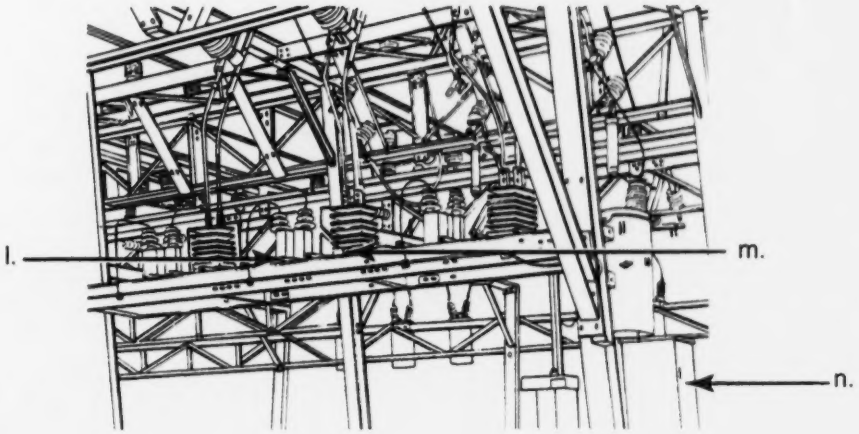
j. _____

k. _____



*May be photocopied for student use.*

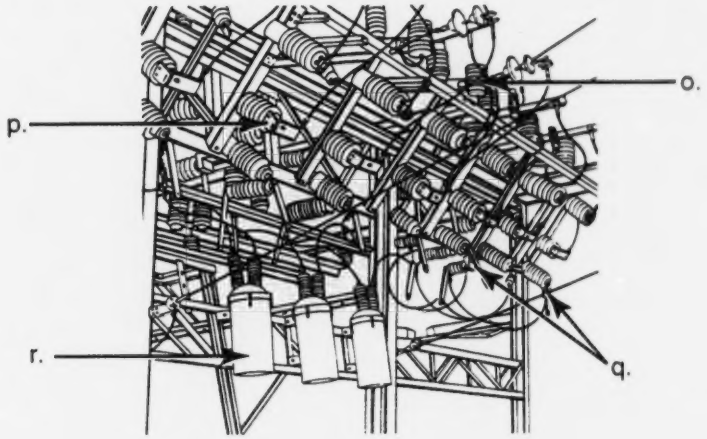
TEST




l. _____

m. _____

n. _____




o. _____

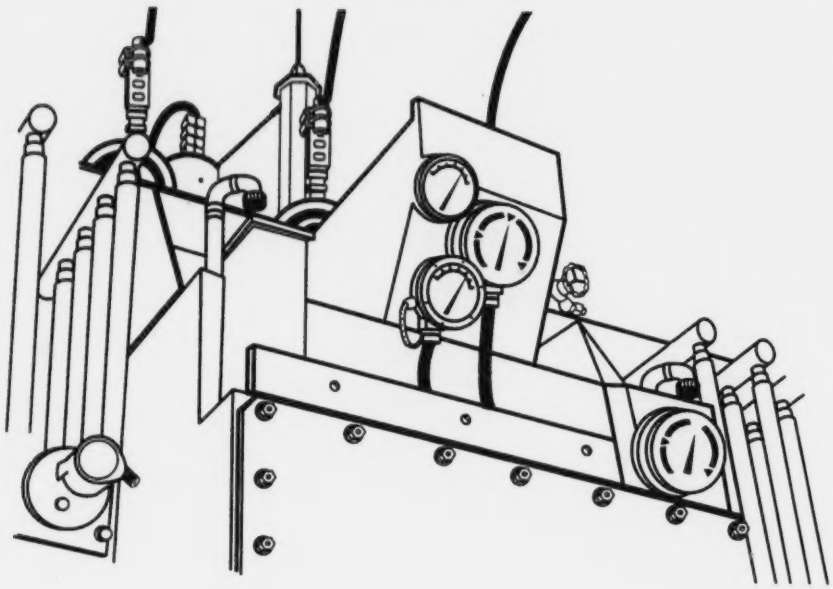
p. _____

q. _____

r. _____

*May be photocopied for student use.*

TEST



s. _____



*May be photocopied for student use.*

TEST

4. Match the substation components on the right to their specific use.

_____a. Supplies power to substation

_____b. Serves as disconnect point between transmission line and substation

_____c. Protects the substation from high voltage surges

_____d. Transforms transmission voltage to distribution voltage and maintains a constant outgoing voltage

_____e. Opens and closes air-break switch

_____f. Indicates tap position, voltage, time delay relay position, and resistance and reactance compensation settings

_____g. Indicates temperature and level of oil

_____h. Supplies potential to kilowatt-hour meter

_____i. Supplies proportionate amount of line current to meter

_____j. Houses meters

_____k. Shows amperage on each phase

_____l. Shows the highest amount of current required and the time it was required

_____m. Shows the kilowatt-hours registered

_____n. Distributes power to each bay of the substation

_____o. Houses three lightning arresters, three bypass switches, and three oil circuit reclosers

_____p. Connects substation and substation fence to grounding grid

1. Bus bar
2. Lightning arrester
3. Voltage regulator
4. Transmission line
5. Substation ground
6. Instantaneous ammeter
7. Air-break switch
8. Transformer-regulator
9. Transformer-regulator indicator gauge
10. Substation bay
11. Metering cabinet
12. Air-break switch operating handle
13. Demand meter
14. Potential transformer
15. Current transformer
16. Kilowatt-hour meter

*May be photocopied for student use.*

TEST

5. Arrange in order the steps for taking a substation out of service by placing a "1" before the first step, a "2" before the second step, and so on.

_____a. Open air-break switch

_____b. Notify your dispatcher

_____c. Lock air-break switch in open position

_____d. Notify power supplier

_____e. Open outgoing oil circuit reclosers and disconnect jumpers

_____f. Check air-break switch visually to see that it is open

6. Select from a list precautions to observe with a substation by placing an "X" in front of the correct precautions.

_____a. Do all work in a substation alone

_____b. Do not store materials in a substation

_____c. Keep substation gates locked except when working inside

_____d. Do not open high side fuses under load

_____e. Do not go into a substation alone

_____f. Open air-break switch under load

_____g. Do not close bypass switches except on oil circuit reclosers

_____h. Do not open air-break switch under load



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TEST

7. Arrange in order the correct procedure for changing a substation oil circuit recloser. Place a "1" before the first procedure, a "2" before the second procedure, and so on.

_____a. Remove cover-up material and barricades

_____b. Disconnect recloser jumpers and clear with insulated stick

_____c. Transfer line jumpers from old recloser to the new one

_____d. Select replacement recloser and place at job site

_____e. Barricade rest of substation to keep workers in specified work area

_____f. Connect recloser jumpers to load and source

_____g. Loosen securing bolts and remove recloser

_____h. Open the newly installed recloser by pulling down on operating handle

_____i. Close recloser bypass switch with insulated stick

_____j. Install new recloser and secure mounting brackets to substation frame

_____k. Open bypass switch with insulated stick

_____l. Open recloser by pulling down on operating handle with insulated stick

_____m. Cover exposed live conductors on either side of recloser with rubber blankets or line hose

_____n. Close newly installed recloser by pushing up on operating handle with insulated stick

_____o. Determine voltage, type, and size of recloser to be changed

*May be photocopied for student use.*

TEST

8. State the correct procedure for bypassing a substation current transformer.

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

9. List three indications in a substation that could cause an outage.

a. _____

b. _____

c. _____

10. Match the indications on the right to the possible problems.

| | | | |
|---|---|---|---|
| _____a. | Burning connection; insulator breakdown; switch not properly closed | 1. | Broken porcelain or glass |
| _____b. | Transformer overloaded; insulation breakdown in windings; cooling fans inoperative | 2. | Oil on ground or structure |
| _____c. | Insulator broken; lightning arrester blown | 3. | Excessive heat in transformer |
| _____d. | Leaking gasket on transformer or recloser; broken bushing on transformer or recloser; hole shot in transformer or recloser | 4. | Arcing sound |



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# GROUNDS AND JUMPERS
# (LINE EQUIPMENT)
# UNIT 3

## SUGGESTED ACTIVITIES

1. Suggested activities for instructor:

   - Provide student with objective sheet.
   - Provide student with information and assignment sheets.
   - Make transparencies.
   - Discuss unit and specific objectives.
   - Discuss information and assignment sheets.
   - Give test.

2. Unit references:

   - Kurtz, Edwin B., and Shoemaker, Thomas M. *The Lineman's and Cableman's Handbook*. 8th ed. New York: McGraw-Hill Book Co., 1992.
   - *Power Line Technician.* Stillwater, OK: Oklahoma Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1978.

GROUNDS AND JUMPERS
(LINE EQUIPMENT)
UNIT 3

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet 1

1. 10 amperes
2. 12 amperes
3. 720 amperes
4. 180 amperes

Assignment Sheet 2

1. 100 volts
2. 200 volts
3. 160 volts
4. 480 volts

GROUNDS AND JUMPERS
(LINE EQUIPMENT)
UNIT 3

ANSWERS TO TEST

1. a. 2
   b. 4
   c. 3
   d. 1
   e. 5
   f. 6
2. a. 2
   b. 3
   c. 1
3. a. Line jumper
      1) Must consist of similar material as the conductor being connected
      2) Must be the same size or ampacity as the conductor being connected
   b. Insulated jumper — Must have insulation value greater than the voltage on which it is used
   c. Ground jumper
      1) Must be large enough to carry unwanted currents
      2) Must be bonded solidly to the conductor or equipment being grounded
4. a, b, d, e, f, g, h, i

ANSWERS TO TEST

5. a. 2
   b. 2
   c. 2
   d. 1, 2
   e. 1, 2
   f. 2
   g. 1

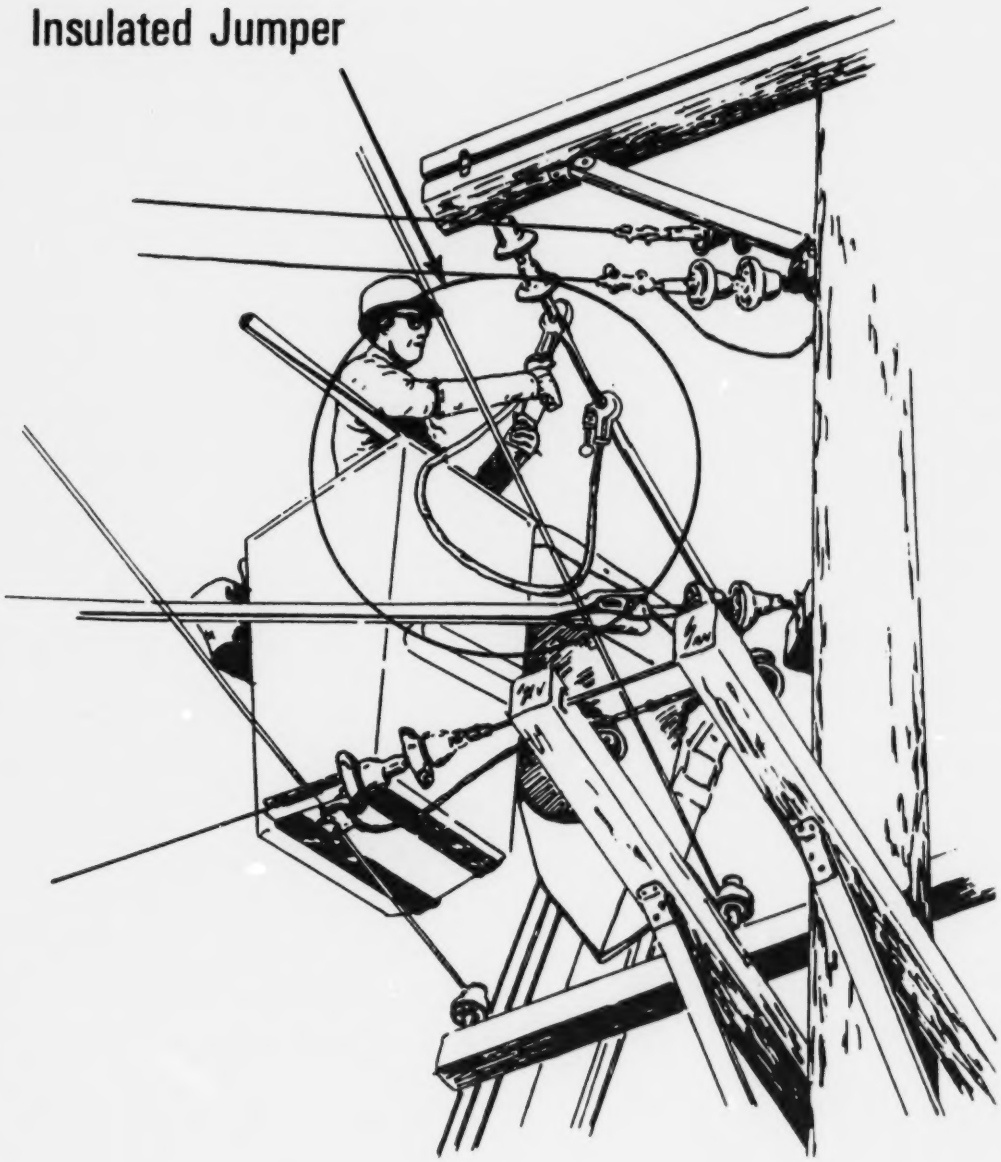
6. a. All metal parts which are not used as energized conductors shall be grounded
   b. All grounded parts shall be interconnected with a metallic conductor extending to the source

7. a. P
   b. I
   c. P
   d. I
   e. I
   f. P

8. Evaluated on Assignment Sheet 1.

9. Evaluated on Assignment Sheet 2.

# Using Insulated Jumper




**The line technician has installed an insulated jumper to keep the circuit closed while a bolt-on connector is being replaced with a crimp-type connector.**



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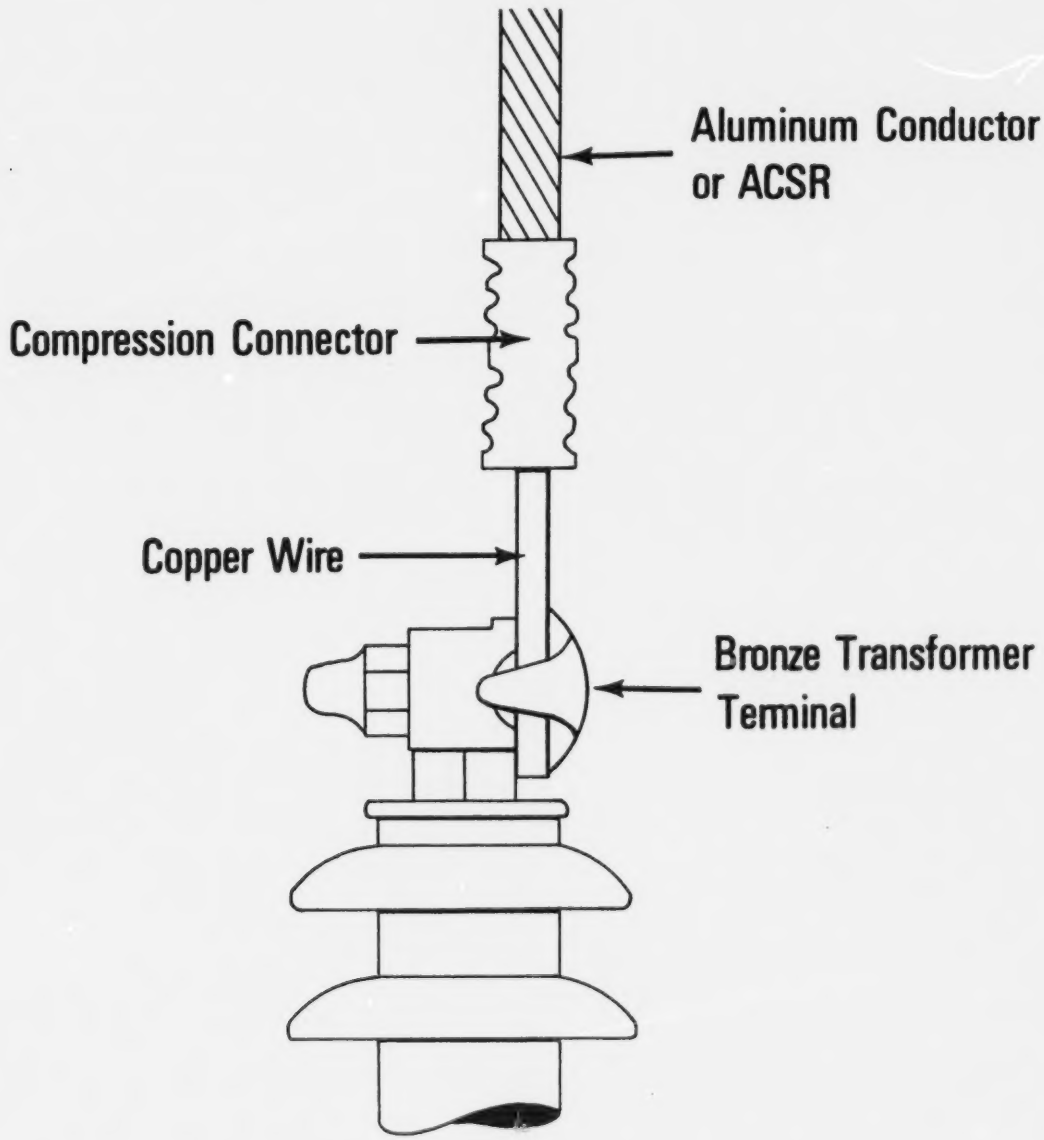
# Safe Connection of Aluminum Conductor to Unplated Bronze Terminal




TM 2

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# GROUNDS AND JUMPERS
# (LINE EQUIPMENT)
# UNIT 3

## TEST

NAME _____ SCORE _____

1. Match terms commonly used with grounds and jumpers on the right to the correct definitions.

| | |
|---|---|
| _____a. Movement of soft metal caused by expansion and contraction or pressure on a small area | 1. Terminal |
| _____b. Two different metals fused together | 2. Cold-flow |
| _____c. Destruction of aluminum conductor when moisture is present at the junction of two different kinds of metal | 3. Electrolytic corrosion |
| _____d. Attachment on line equipment used to connect a conductor | 4. Bi-metal |
| _____e. Short piece of wire used to close an opening in a circuit | 5. Jumper |
| _____f. Coating on terminal or connector to make it suitable for copper or aluminum conductors | 6. Plating |

2. Match types of jumpers to their specific use.

| | |
|---|---|
| _____a. Connects opening in line conductor while changes or repairs are being made | 1. Line jumper |
| _____b. Connects line neutral at corners and double dead ends; connects line equipment to neutral and pole ground | 2. Insulated jumper |
| _____c. Connects line conductor at corners and double dead ends; connects line equipment to line conductor | 3. Grounding jumper |



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TEST

3. State one requirement for each of the following types of jumpers.

   a. Line jumper — _____

   _____

   b. Insulated jumper — _____

   _____

   c. Grounding jumper — _____

   _____

4. Select from a list the line equipment that is connected by jumpers by placing an "X" in front of the correct equipment.

   _____a. Line switch

   _____b. Voltage regulator

   _____c. Crossarm

   _____d. Capacitor

   _____e. Lightning arrester

   _____f. Transformer

   _____g. Oil circuit recloser

   _____h. Fuse cut-out

   _____i. Sectionalizer



*May be photocopied for student use.*

TEST

5. Match types of jumpers on the right to the correct installation methods. (Some answers include both kinds of jumpers.)

| | | |
|---|---|---|
| _____a. | Install with copper ends when connecting to bronze or unplated terminals | 1. Copper |
| _____b. | Install with aluminum connector | 2. Aluminum |
| _____c. | Install with coating of inhibitor | |
| _____d. | Install with bi-metal or plated connector | |
| _____e. | Install with slack to avoid vibration damage | |
| _____f. | Install with large area or compression connector | |
| _____g. | Install with copper or compression connector | |

6. State two requirements for safe grounding of line equipment.

a. _____

_____

_____

b. _____

_____

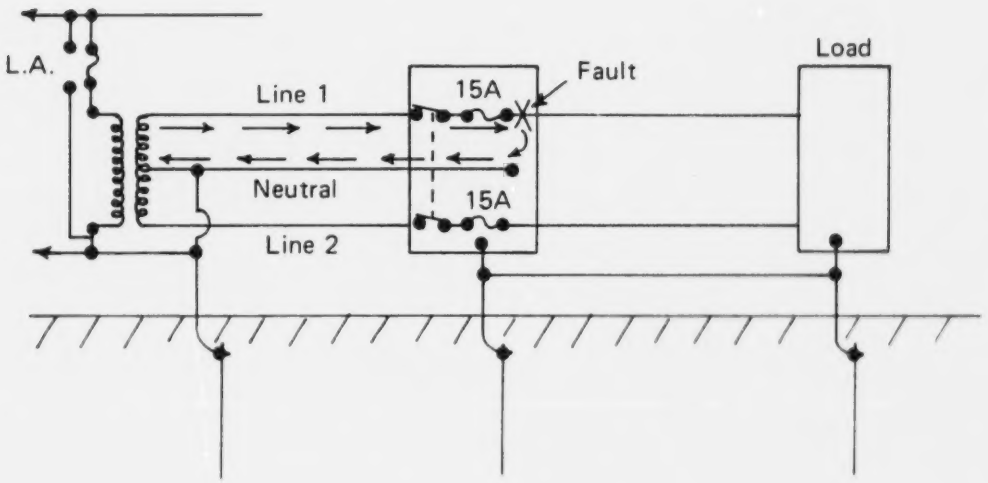
_____



*May be photocopied for student use.*

TEST

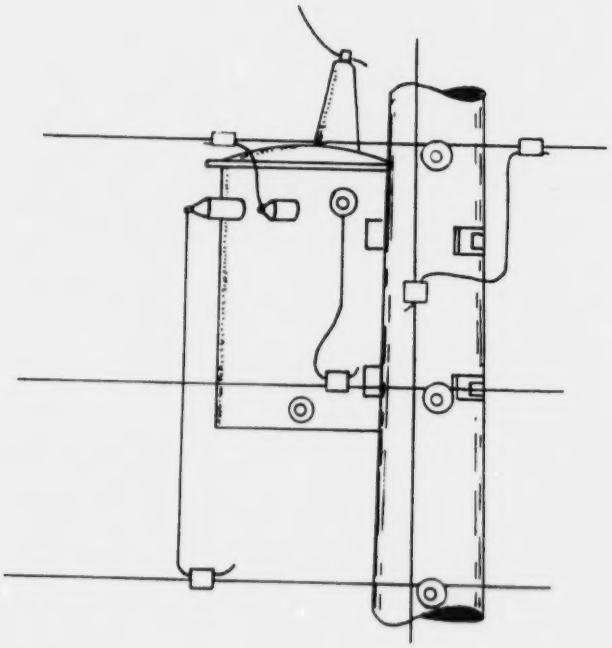
7. Distinguish between proper and improper grounding methods by placing a "P" in the blank by the equipment which is properly grounded and an "I" by the improperly grounded equipment.



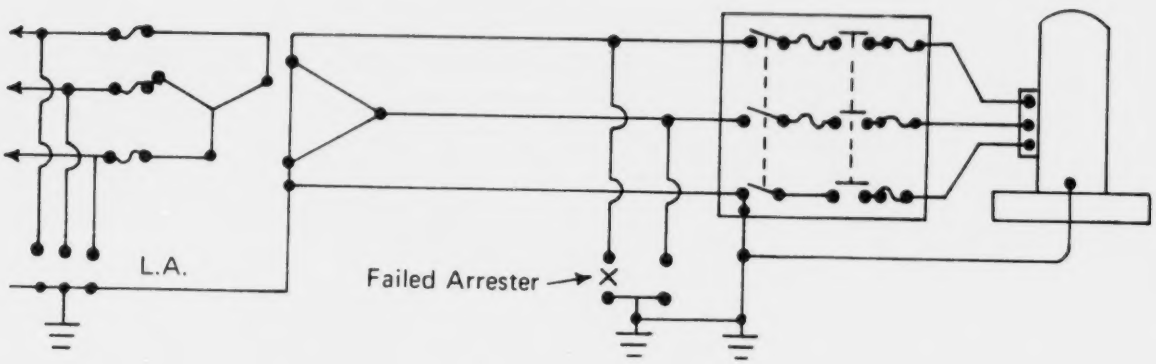

a. _____

*May be photocopied for student use.*

TEST



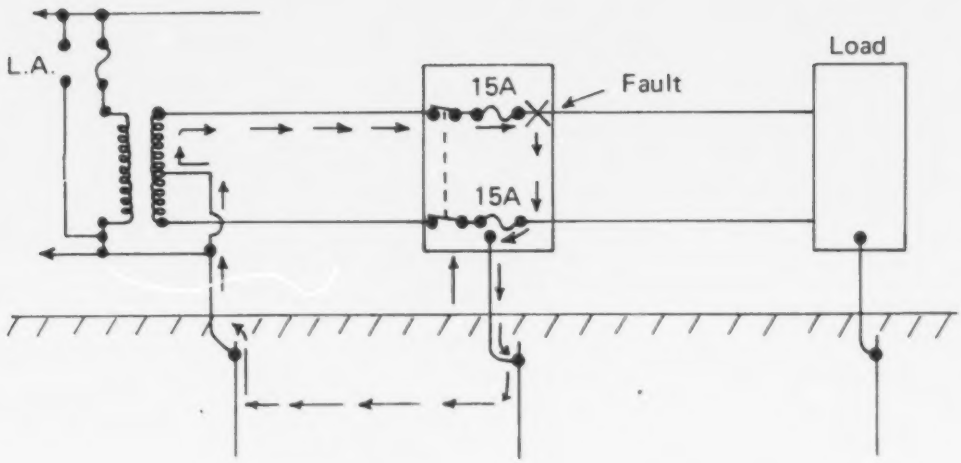
b. _____



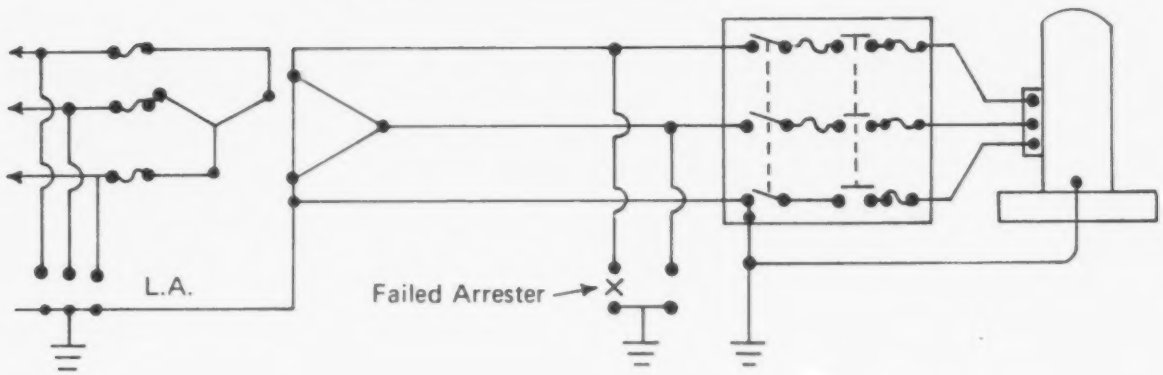

c. _____

*May be photocopied for student use.*

TEST




d. _____




e. _____

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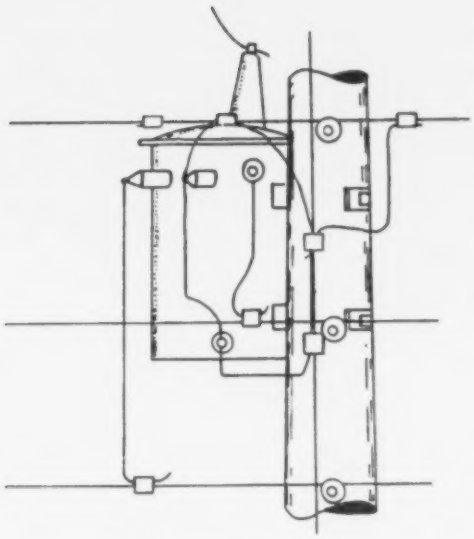
TEST



f. _____

8. Evaluated on Assignment Sheet 1.

9. Evaluated on Assignment Sheet 2.

*May be photocopied for student use*

# VOLTAGE AND CURRENT MEASURING
# UNIT 4

## SUGGESTED ACTIVITIES

1. Suggested activities for instructor:

   - Provide student with objective sheet.
   - Provide student with information sheet.
   - Discuss unit and specific objectives.
   - Discuss information sheet.
   - Display voltage and current measuring instruments.
   - Give test.

2. Unit references:

   - *Power Line Technician.* Stillwater, OK: Oklahoma Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1978.

# VOLTAGE AND CURRENT MEASURING
# UNIT 4

## ANSWERS TO TEST

1. a. 3
   b. 6
   c. 5
   d. 7
   e. 2
   f. 1
   g. 4
   h. 9
   i. 8

2. a. Provide valuable information for the operation and development of an electrical system
   b. Provide basic data for maintaining adequate voltage levels and current balance

3. a. Variable voltage source
   b. Socket-type indicating ammeter
   c. Voltage tester
   d. Kilowatt-hour, volt, and ammeter test block
   e. Socket-type voltmeter
   f. Clamp-on volt-ammeter
   g. Voltmeter
   h. Primary line ammeter
   i. Recording voltmeter
   j. Shop standard voltmeter

4. a. Check voltage at source (transformer)
   b. Check voltage at delivery point (meter)
   c. Subtract delivery point reading from source reading

## ANSWERS TO TEST

5. a. Install three clamp-on type indicating ammeters on one circuit at substation

   b. Install three clamp-on type indicating ammeters on the same circuit a few miles from substation

6. a. Read demand on demand meter and multiply by meter multiplier to obtain kW demand

   b. Install indicating ammeter on secondary side of transformer

7. a. Install recording voltmeter at the substation

   b. Install recording voltmeter at or near the end of the primary line

   c. Subtract the voltage at the end of the primary line from the substation voltage

8. a, c, d, e, f, g, h

9. a. 2 f. 1

   b. 2 g. 1

   c. 2 h. 1

   d. 2 i. 2

   e. 1

10. a, b, c, d, e, g, h

# VOLTAGE AND CURRENT MEASURING
## UNIT 4

## TEST

NAME _____ SCORE _____

1. Match the terms commonly used with voltage and current measurements on the right to the correct definitions.

| | | |
|---|---|---|
| _____a. | Voltmeter which gives instantaneous maximum and minimum readings | 1. Shop standard |
| _____b. | Voltmeter which records voltage and time readings on a tape or chart | 2. Peak load |
| _____c. | Minimum and maximum voltage from a 120-volt base | 3. Indicating voltmeter |
| _____d. | Source output voltage minus the voltage at the end of the line | 4. Voltage spread |
| _____e. | Time during a day when maximum line current is flowing | 5. Voltage levels |
| _____f. | Meter used to calibrate instruments used for actual testing | 6. Recording voltmeter |
| _____g. | Limit that service voltage varies from recommended base | 7. Voltage drop |
| _____h. | Meter which indicates whether the line current leads or lags the voltage in electrical degrees | 8. Ammeter |
| _____i. | Meter which indicates current flow in amperes | 9. Power factor meter |

2. State two of the purposes of voltage and current measurements.

a. _____

_____

_____

*May be photocopied for student use.*

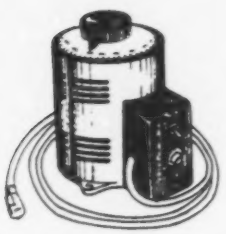
TEST

b. _____

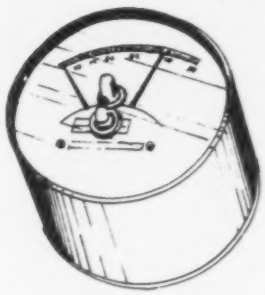
_____

_____

3. Identify equipment used for voltage and current measurements. Write the correct name in each blank.



a. _____



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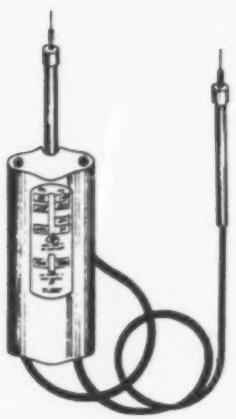
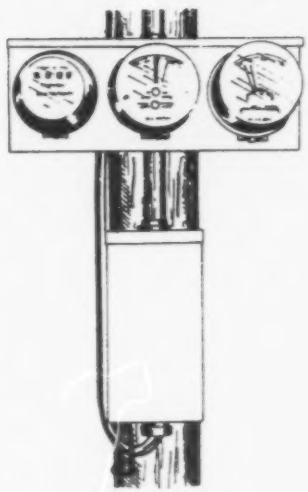


c. _____



d. _____

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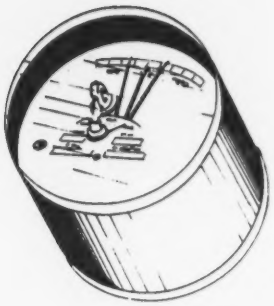
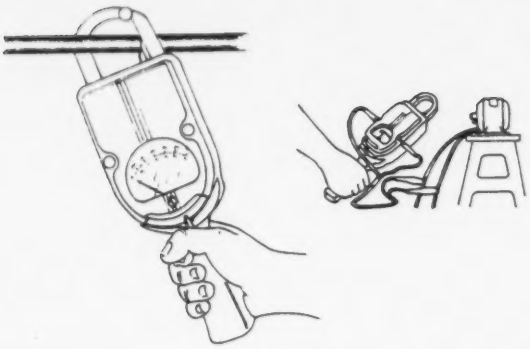
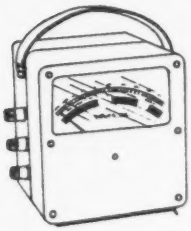
TEST



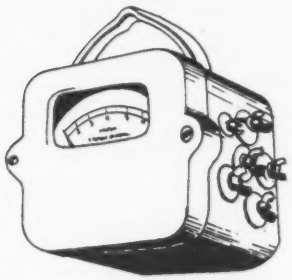
e. _____



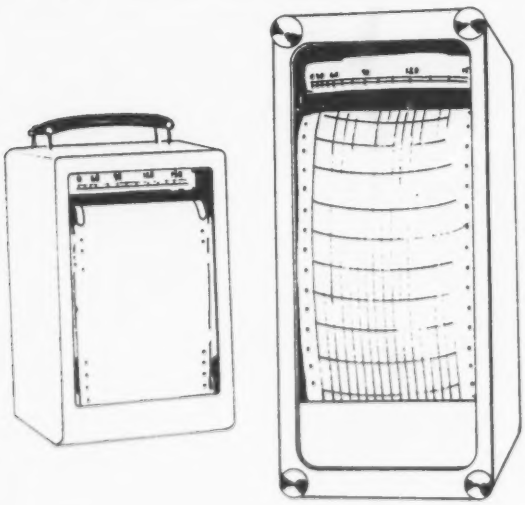
f. _____



g. _____



h. _____



i. _____

j. _____

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TEST

4. State the correct procedure for determining voltage drop of a service.

   a. _____

   b. _____

   c. _____

5. State the correct procedure for determining current demand on a primary circuit in a specific area.

   a. _____

   _____

   b. _____

   _____

6. State procedures for determining current demand on a transformer.

   a. _____

   _____

   _____

   b. _____

   _____

   _____

7. List steps to obtain primary line voltage drop.

   a. _____

   _____

   b. _____

   _____

   c. _____

   _____

*May be photocopied for student use.*

TEST

8. Select from a list reasons for current measurements. Place an "X" in front of the correct reasons.

_____a. Oil circuit recloser loading

_____b. Placement of lightning arresters

_____c. Individual circuit demand

_____d. Voltage-regulator line drop compensation settings

_____e. Substation transformer and regulator loading

_____f. Substation ampere demand

_____g. Phase balance of each circuit

_____h. Measurement of transformer loading

9. Match the full load secondary currents at 240 volts single phase (on the right) to the kVA ratings of a transformer (on the left).

| | | |
|---|---|---|
| _____a. | 3 kVA | 1. 10.3 amperes<br>2. 12.5 amperes |
| _____b. | 25 kVA | 1. 208.33 amperes<br>2. 104.17 amperes |
| _____c. | 10 kVA | 1. 20.83 amperes<br>2. 41.67 amperes |
| _____d. | 100 kVA | 1. 208.33 amperes<br>2. 416.67 amperes |
| _____e. | 75 kVA | 1. 312.50 amperes<br>2. 208.33 amperes |
| _____f. | 5 kVA | 1. 20.83 amperes<br>2. 41.67 amperes |
| _____g. | 37.5 kVA | 1. 156.25 amperes<br>2. 208.33 amperes |
| _____h. | 50 kVA | 1. 208.33 amperes<br>2. 156.25 amperes |
| _____i. | 15 kVA | 1. 41.67 amperes<br>2. 62.50 amperes |

*May be photocopied for student use.*

TEST

10. Select from a list precautions to observe when making voltage and current measurements. Place an "X" in front of the correct precautions.

_____a. Attach ammeter in series with line, never in parallel

_____b. Wear your protective equipment always

_____c. Do not leave exposed energized connections when setting a recording meter

_____d. Do not install ammeters on a primary line by hand; always use a hot stick

_____e. Set voltmeter on highest scale before applying to voltage

_____f. Attach voltmeter in series with line

_____g. Transport and handle all instruments carefully

_____h. Set ammeter on high scale before checking amperage

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# A CIMC "RAINBOW PROGRAM"

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One very important factor contributing to higher student performance is the expectation of parents and teachers. Experience suggests that teachers and parents who expect student success find that students perform better, attend class more regularly, have positive attitudes, and stay in school longer. The students' success and confidence in their ability to learn may cause additional growth and behaviors that exert a positive influence throughout life.

## STUDENT'S PROMISE

***Let it be publicly known that students in this program have high expectations of***

I recognize that America's future is dependent on my success in school.
I will attend school regularly.
I will keep regular study hours at home.
I will read each day at home.
I will never accept failure.
I will accept responsibility for my school challenges.
I will respect the rights and feelings of others at home, school, and work.
I will develop positive qualities in myself that my friends will admire.
If I have difficulty, I will insist on help with my school work.
If I have difficulty, I will always try harder.
I will ask my teacher for clear learning objectives.
I will practice good citizenship skills at home, school, and work.
I will keep my parents/guardians informed daily about my school activities.
I will develop goals for school, home, and work.
I will seek advice from my teachers, parents/guardians, and counselors on career guidance.
I will constantly practice the skills of a good student.

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# Power Line Technician

Second Edition

## Module D

- Insulation
- Substations
- Grounds and Jumpers (Line Equipment)
- Voltage and Current Measuring

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Student Workbook

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TI3018

# Power Line Technician: Module D

## Student Workbook

Developed by the
Curriculum and Instructional Materials Center
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# INSULATION
# UNIT 1

## UNIT OBJECTIVE

After completion of this unit, the student should be able to select from a list methods of insulating distribution voltages and transmission voltages on wooden structures. The student should be able to select from a list precautions to observe with insulators and insulation. This knowledge will be evidenced by scoring 85 percent on the unit test.

## SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms commonly associated with insulators and insulation to their correct definitions.
2. List steps to follow when installing a pin type insulator.
3. Select from a list methods of insulating distribution voltages.
4. Select from a list methods of insulating various transmission voltages on wooden structures.
5. Match insulative materials to their specific uses.
6. Select from a list precautions to observe with insulators and insulation.

INSULATION
UNIT 1

INFORMATION SHEET

1. Match terms commonly associated with insulators and insulation to their correct definitions.

   - Flashover — Arc between an energized conductor and hardware over an insulator
   - Suspension insulator — Insulator which can be joined to others to form a string of insulators (Transparency 1)
   - Post insulator — Insulator which mounts by means of a stud bolt in the base of the insulator (Transparency 2)
   - Side post insulator — Insulator which bolts to the side of a structure in a horizontal position (Transparency 3)
   - Pin insulator — Insulator which mounts on a steel pole top or crossarm pin (Transparency 4)
   - Spool insulator — Insulator which mounts on an upset bolt, with a clevis, or on a rack (Transparency 4)
   - Porcelain — Material used to make insulators; made from kaolin, quartz, and feldspar
   - Fiberglass — High strength, rigid insulative material
   - Cross-linked polyethylene (XLPE) — Tough, flexible insulation whose atoms are chemically bonded
   - Low density, high molecular weight polyethylene (HMPE) — Solid, tough, flexible insulation
   - Ethylene propylene (EP) — Thermosetting, rubber-like insulation
   - Hi-dialectric — Any substance with high resistance to current flow
   - Natural rubber — Flexible, hi-dialectric insulation
   - Molecule — Smallest element of a substance which retains its identity in a mass
   - Ozone — Gas generated from an electric arc which will destroy natural rubber
   - Basic insulation level (BIL) — Level at which insulation can withstand a voltage impulse without breaking down

     (NOTE: The basic insulation level is stated in kilovolts.)

INFORMATION SHEET

2. List steps to follow when installing a pin type insulator.

   - Check for cracks or chips
   - Screw insulator onto pin
   - Align top groove with conductor
   - Install tie

   (NOTE: Always wear gloves when handling insulators to prevent injury.)

3. Select from a list methods of insulating distribution voltages.

   - 7,200-volt dead ends and angles
     1. Two 4 1/4" suspension insulators
     2. Two 6" suspension insulators
   - 14,400-volt dead ends and angles
     1. Three 4 1/4" suspension insulators
     2. Three 6" suspension insulators
     3. Two 10" suspension insulators

4. Select from a list methods of insulating various transmission voltages on wooden structures.

   - 69,000-volt vertical suspension, dead ends, and angles
     1. Four 10" suspension insulators on vertical suspension
     2. Six 10" suspension insulators on horizontal angles
     3. Six 10" suspension insulators on dead ends
   - 138,000-volt vertical suspension, dead ends, and angles
     1. Nine 10" suspension insulators on vertical suspension
     2. Ten 10" suspension insulators on horizontal angles
     3. Eleven 10" suspension insulators on dead ends

INFORMATION SHEET

(NOTE: An additional insulator is added on steel structures and may be added on other structures to increase clearance from the structure.)

5. Match insulative materials to their specific uses.

   - Porcelain — Used in the manufacture of pin, suspension, and bushing insulators
   - Tempered glass — Used in the manufacture of pin and suspension insulators
   - Fiberglass — Used in the manufacture of hot line tools, cover-up material, and hot line equipment
   - XLPE — Used as a covering on overhead and underground low voltage cable
   - EP — Used for cable insulation up to 35 kV
   - HMPE — Used for cable insulation above and below 35 kV
   - Natural rubber — Used in the manufacture of rubber gloves, rubber sleeves, and cover-up materials

6. Select from a list precautions to observe with insulators and insulation.

   - Wear gloves when handling porcelain or glass insulators
   - Transport insulators in cartons to avoid breakage
   - Store rubber goods away from electrical equipment
   - Do not fold rubber protective equipment
   - Keep rubber goods away from petroleum products
   - Clean rubber goods often with mild detergent
   - Check protective and cover-up material daily for cracks, cuts, or deterioration
   - Store rubber goods away from heat and sunlight

# SUBSTATIONS
# UNIT 2

## UNIT OBJECTIVE

After completion of this unit, the student should be able to identify and state the functions of substation components. The student should be able to select from a list precautions to observe with a substation and be able to state procedures for changing a substation oil circuit recloser and bypassing a current transformer. The student should be able to recognize indications of a problem in a substation. This knowledge will be evidenced by scoring 85 percent on the unit test.

## SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms commonly used with substations to the correct definitions.
2. State functions of a substation.
3. Identify components of a substation.
4. Match components of a substation to their specific use.
5. Arrange in order the steps for taking a substation out of service.
6. Select from a list precautions to observe with a substation.
7. Arrange in order the correct procedure for changing a substation oil circuit recloser.
8. State the correct procedure for bypassing a substation current transformer.
9. List indications in a substation that could cause an outage.
10. Match indications to problems which may occur in substations.

SUBSTATIONS
UNIT 2

INFORMATION SHEET

1. Match terms commonly used with substations to the correct definitions.

   - High side fuse — Fuse which protects the transmission line from a short circuit in a substation
   - Grounding grid — Buried metal mat or conductor under and around a substation
   - Station arrester — Lightning arrester designed to protect a substation transformer from high voltage surges
   - Air-break switch — Switch designed to open a circuit which is not under heavy load
   - Bypass switch — Switch designed to change current flow around a piece of equipment
   - Bus — Heavy conductor made of copper or aluminum wire or bar which distributes current in a substation
   - Oil circuit recloser — Switch which protects the substation transformer from short circuits on distribution lines
   - Bay — Section of a substation which contains one secondary three-phase circuit
   - Vacuum recloser — Switch used for heavy loads, usually above 200 amperes
   - Personal protective equipment — Includes, but is not limited to, gloves, gowns, laboratory coats, face shields or masks and eye protection, and mouth pieces, resuscitation bags, pocket masks, and other ventilation devices

     (NOTE: Wear and use personal protective equipment provided while in substations.)

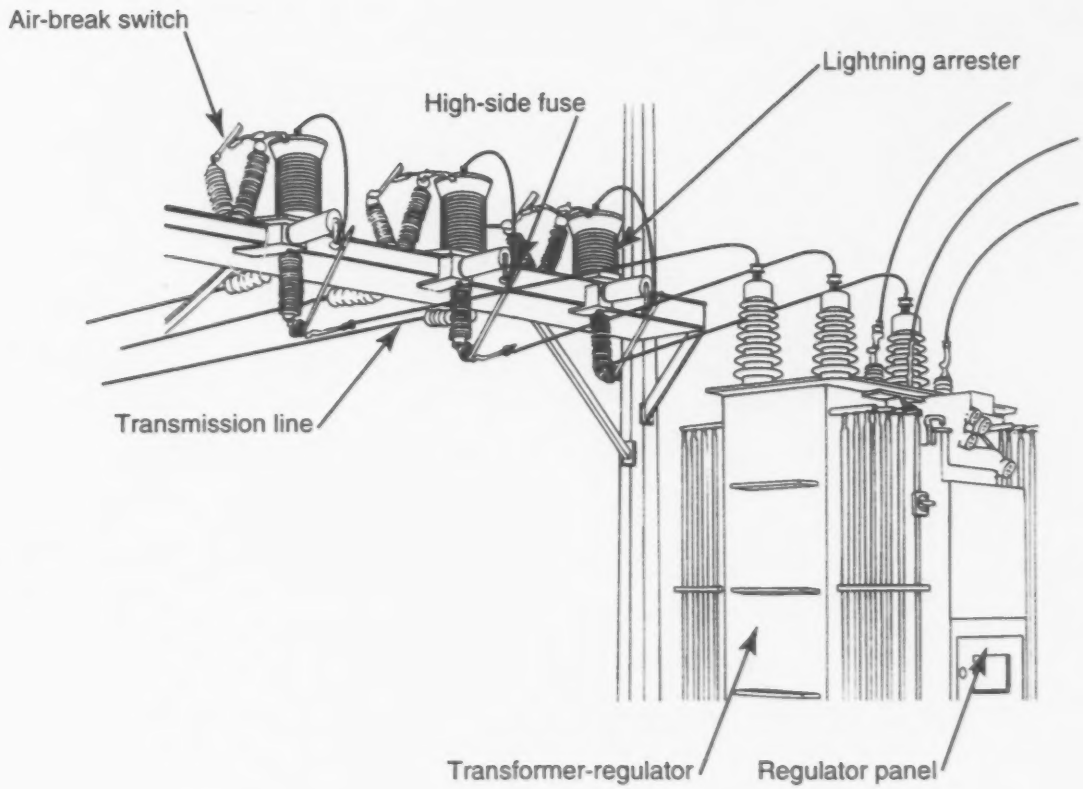
2. State functions of a substation.

   - Provide a distribution point as close as possible to a load center
   - Provide a metering point for distribution power
   - Provide protection for the power transformer and the transmission line
   - Transform transmission voltage to distribution voltage
   - Regulate voltage

INFORMATION SHEET

3. Identify components of a substation

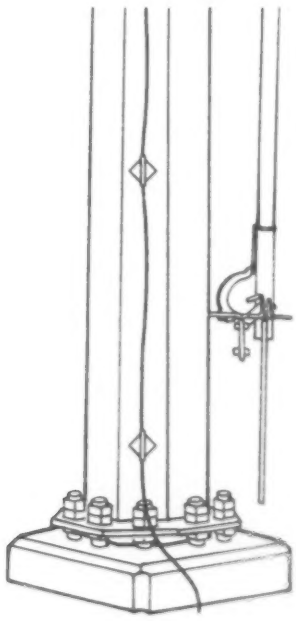
- Transmission line
- Air-break switch (three-phase)
- Lightning arrester (station type)
- Transformer-regulator




(NOTE: This transformer is a combination power transformer and voltage regulator. The voltage regulator may be a separate unit in some substations. Voltage regulations may be accomplished with one three-phase unit or three single-phase units.)

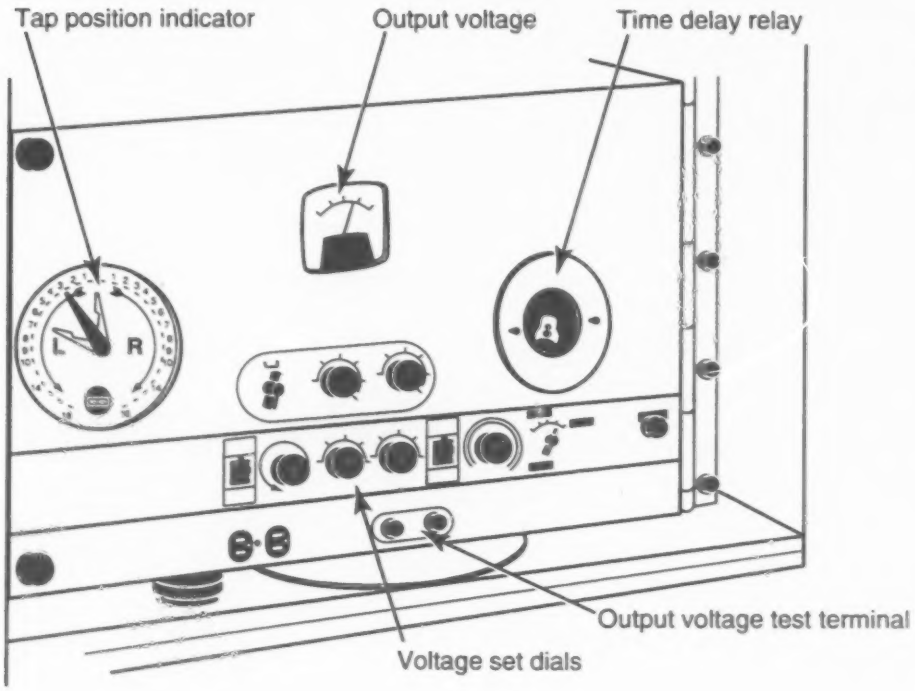
INFORMATION SHEET

- Air-break switch operating handle



INFORMATION SHEET

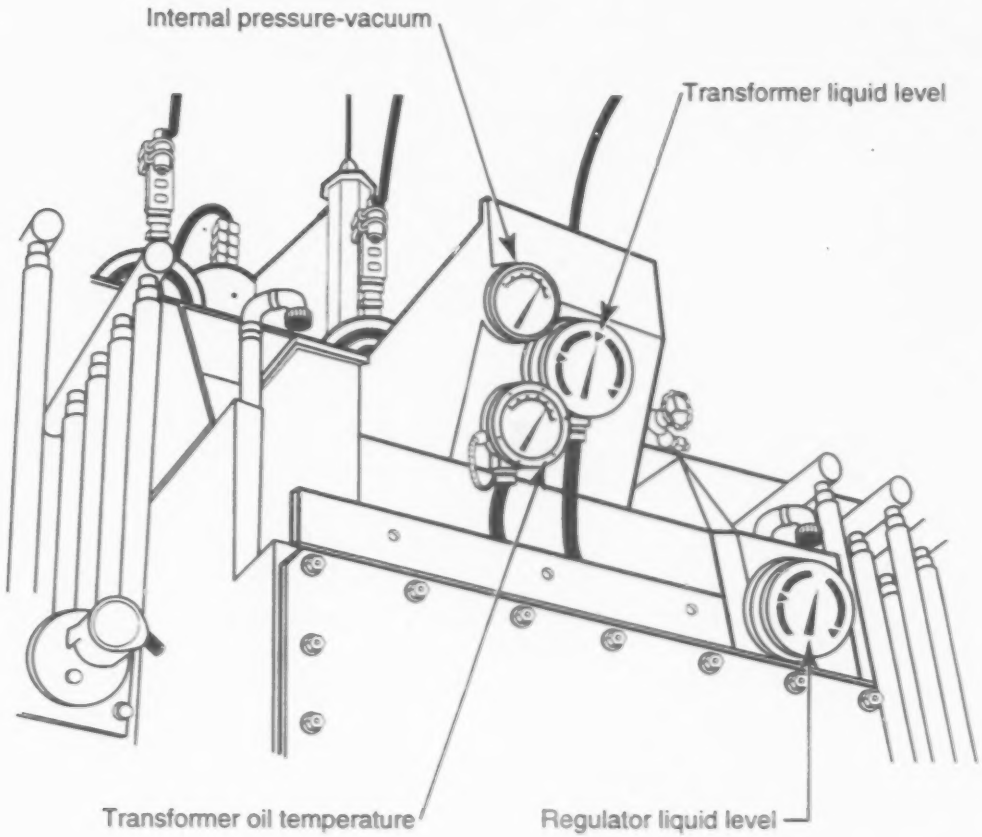
- Voltage regulator panel




(NOTE: A built-in transformer in the regulator supplies potential for the output voltage meter and power for the tap changer drive unit.)

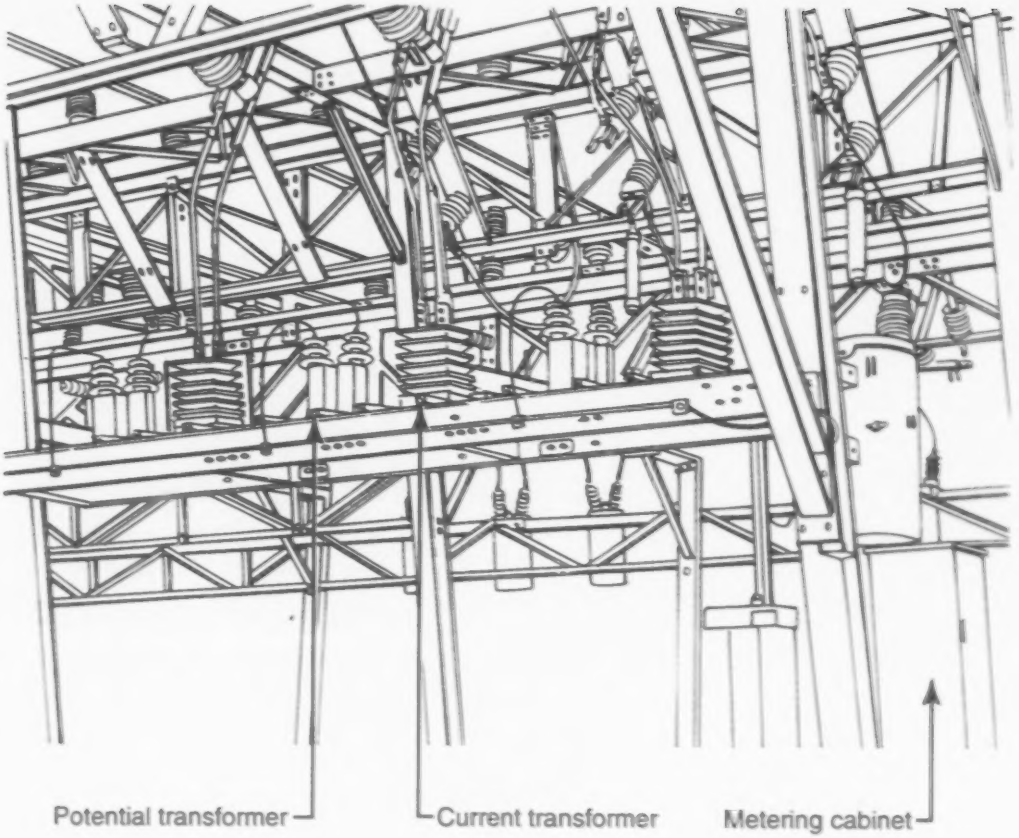
INFORMATION SHEET

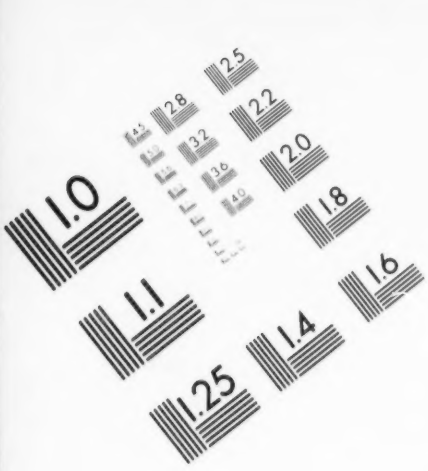
- Transformer-regulator indicator gauges



INFORMATION SHEET

- Potential transformers
- Current transformers
- Metering cabinet





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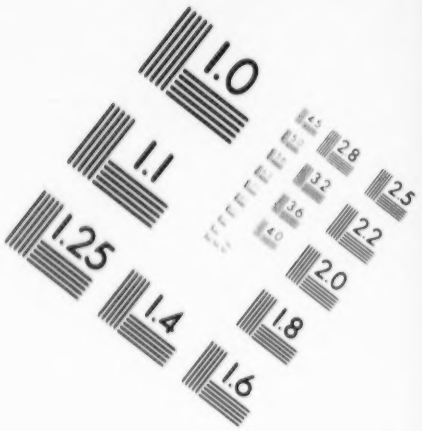


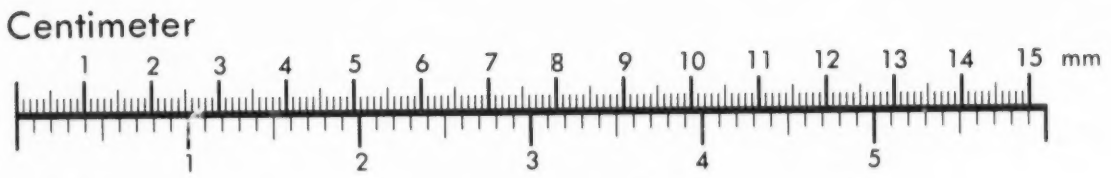


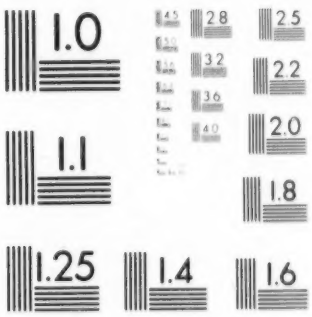

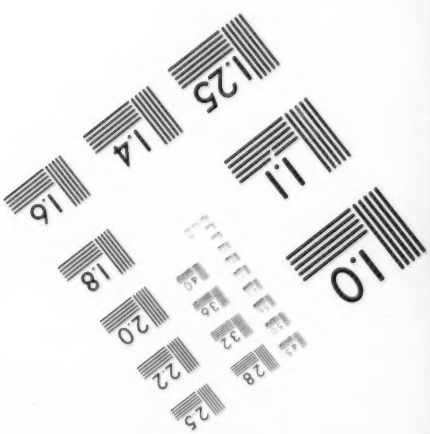


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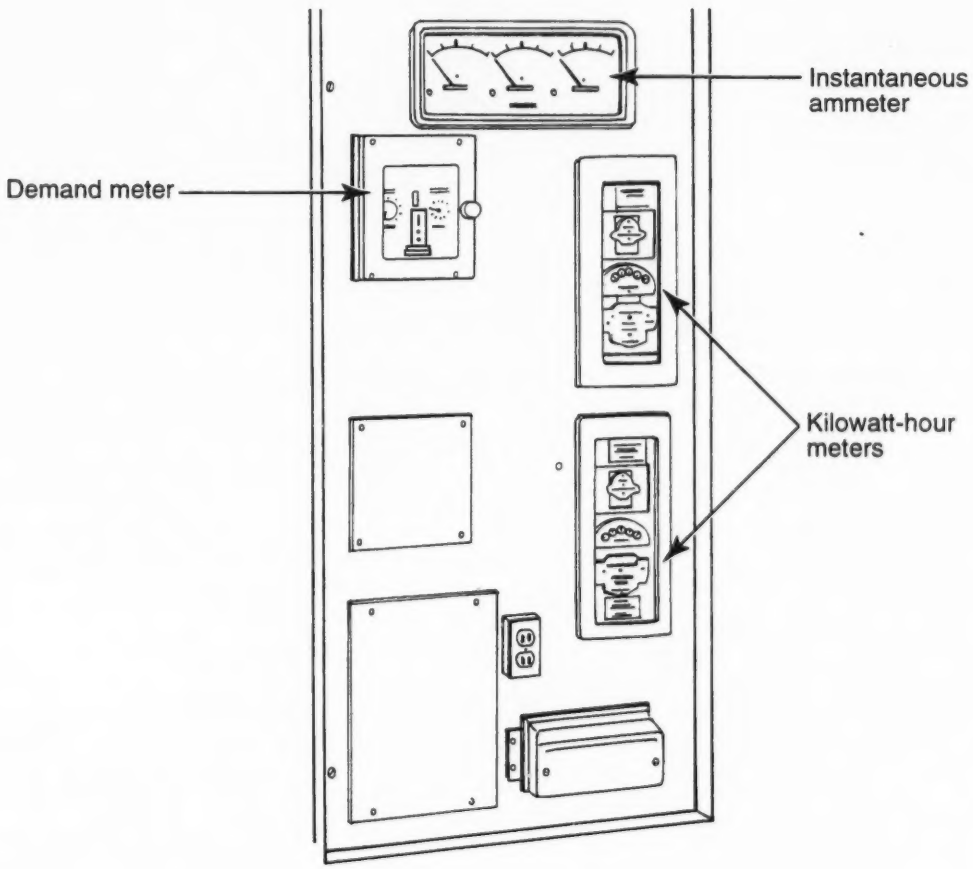
BY APPLIED IMAGE, INC.

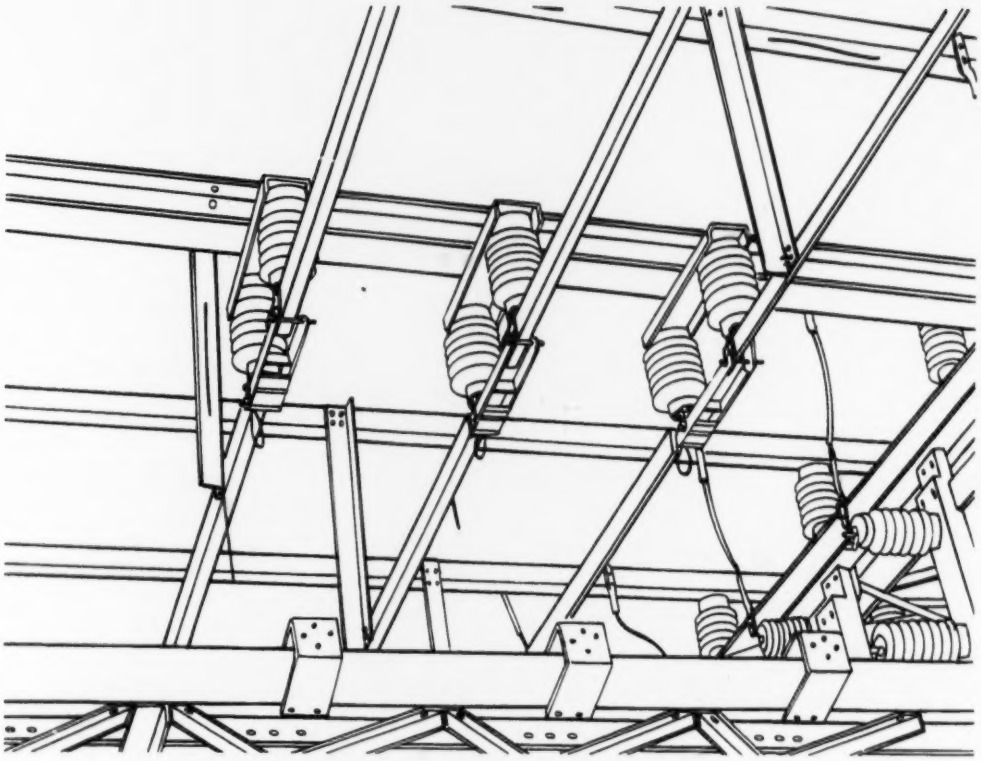
INFORMATION SHEET

- Instantaneous ammeters
- Demand meter with timed and printed tape
- Kilowatt-hour meters



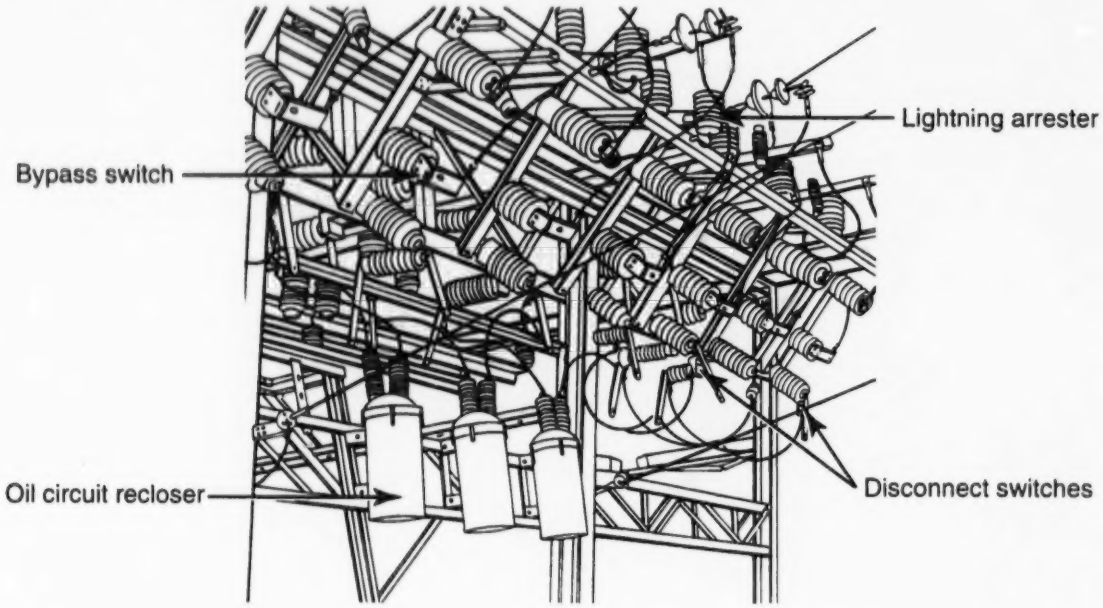
INFORMATION SHEET

- Bus bars with disconnect switches



INFORMATION SHEET

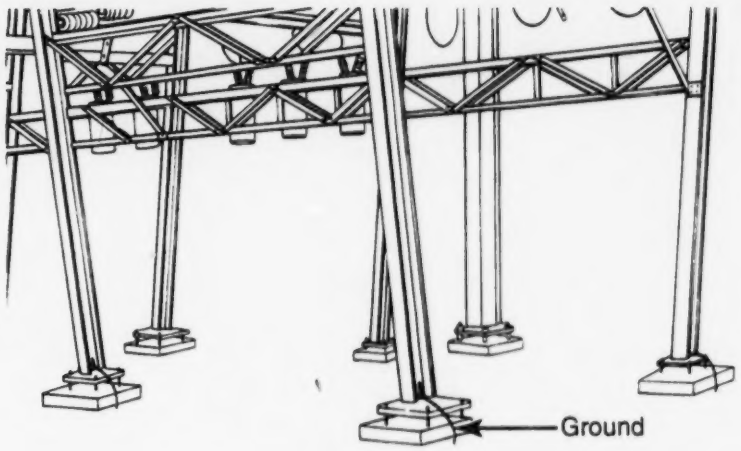
- Lightning arresters
- Bypass switches (with bypass fuses removed)
- Disconnect switches
- Oil circuit reclosers




**(Warning — When working on this type switch, be sure to have the right switch open or closed.)**

INFORMATION SHEET

- Substation ground




(NOTE: Each leg of the substation and each section of fence are solidly grounded to the ground grid under and around the substation.)

4. Match components of a substation to their specific use.

- Transmission line — Supplies power to substation
- Air-break switch — Serves as disconnect point between transmission line and substation
- Lightning arrester — Protects the substation from high voltage surges
- Transformer-regulator — Transforms transmission voltage to distribution voltage and maintains a constant outgoing voltage
- Air-break switch operating handle — Opens and closes air-break switch

  (NOTE: Before opening handle put on rubber gloves and keep both feet on ground plate. Touch and step potential.)
- Voltage regulator panel — Indicates tap position, voltage, time delay relay position, and resistance and reactance compensation settings
- Transformer-regulator indicator gauge — Indicates temperature and level of oil
- Potential transformer — Supplies proportionate amount of line current to meter
- Current transformer — Supplies proportionate amount of line current to meter
- Metering cabinet — Houses meters

INFORMATION SHEET

- Instantaneous ammeter — Shows amperage on each phase
- Demand meter — Shows the highest amount of current required and the time it was required
- Kilowatt-hour meter — Shows the kilowatt hours registered
- Bus bar — Distributes power to each bay of the substation
- Substation bay — Houses three lightning arresters, three bypass switches, and three oil circuit reclosers
- Substation ground — Connects substation and substation fence to grounding grid

5. Arrange in order the steps for taking a substation out of service.

   (NOTE: Repeat and verify instructions.)

   - Notify your dispatcher
   - Notify power supplier
   - Open outgoing oil circuit reclosers and disconnect jumpers
   - Open air-break switch
   - Check air-break switch visually to see that it is open
   - Lock air-break switch in open position

     (NOTE: Substation sites are sometimes used for a switching station for transmission lines.)

6. Select from a list precautions to observe with a substation.

   - Do not go into a substation alone
   - Do not store materials in a substation
   - Do not close bypass switches except on oil circuit reclosers
   - Do not open high side fuses under load
   - Do not open air-break switch under load
   - Keep substation gates locked except when working inside

INFORMATION SHEET

7. Arrange in order the correct procedure for changing a substation oil circuit recloser.

(NOTE: Notify the dispatcher before any work is performed.)

- Determine voltage, type, and size of recloser to be changed
- Select replacement recloser and place at job site
- Barricade rest of substation to keep workers in specified work area
- Close recloser bypass switch with insulated stick
- Open recloser by pulling down on operating handle with insulated stick
- Disconnect recloser jumpers and clear with insulated stick
- Cover exposed live conductors on either side of recloser with rubber blankets or line hose
- Loosen securing bolts and remove recloser
- Transfer line jumpers from old recloser to the new one
- Install new recloser and secure mounting brackets to substation frame
- Open the newly installed recloser by pulling down on operating handle
- Connect recloser jumpers to load and source
- Close newly installed recloser by pushing up on operating handle with insulated stick
- Open bypass switch with insulated stick
- Remove cover-up material and barricades

(NOTE: All work in a substation will be done in close proximity to energized parts unless the station is taken out of service. Always wear your personal protective equipment. Always ground and place hold cards on the de-energized circuits.)

INFORMATION SHEET

8. State the correct procedure for bypassing a substation current transformer.

   - Take the substation out of service
   - Ground the circuit
   - Remove jumpers from current transformer
   - Remove current transformer
   - Connect current transformer jumpers together

     (NOTE: Do not cut the jumpers. They will be used to connect the new current transformer.)

   - Put substation back in service

     (NOTE: Bypassing a current transformer is an emergency procedure to get a substation back in service. Some newer substations may have bypass switches for the current transformers.)

9. List indications in a substation that could cause an outage.

   - Arcing sound
   - Bird's nest in the structure

     (NOTE: Snakes frequently cause outages in a substation while trying to reach a bird's nest.)

   - Excessive heat in the power transformer

     (NOTE: A heat-indicating gauge on the power transformer has two pointers. One pointer indicates the internal temperature; the other pointer indicates the maximum temperature that the transformer has reached.)

   - Excessive noise in transformer, regulator, or metering equipment

10. Match indications to problems which may occur in substations.

    - Arcing sound

      1. Burning connection
      2. Insulator breakdown
      3. Switch not properly closed

INFORMATION SHEET

- Excessive heat in transformer
  1. Transformer overloaded
  2. Insulation breakdown in windings
  3. Cooling fans inoperative
- Broken porcelain or glass
  1. Insulator broken
  2. Lightning arrester blown
- Oil on ground or structure
  1. Leaking gasket on transformer or recloser
  2. Broken bushing on transformer or recloser
  3. Hole shot in transformer or recloser

# GROUNDS AND JUMPERS
# (LINE EQUIPMENT)
# UNIT 3

## UNIT OBJECTIVE

After completion of this unit, the student should be able to select and install jumpers. The student should be able to safely ground line equipment and determine proper and improper grounding methods. This knowledge will be evidenced by scoring 85 percent on the unit test.

## SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms commonly used with grounds and jumpers to the correct definitions.
2. Match types of jumpers to their specific use.
3. State requirements for various jumpers.
4. Select from a list the line equipment that is connected by jumpers.
5. Match types of jumpers to the correct installation methods.
6. State the requirements for safe grounding of line equipment.
7. Distinguish between proper and improper grounding methods.
8. Calculate current flow of faulted equipment which is improperly grounded. (Assignment Sheet 1)
9. Calculate voltage on improperly grounded faulted equipment. (Assignment Sheet 2)

# GROUNDS AND JUMPERS
# (LINE EQUIPMENT)
# UNIT 3

## INFORMATION SHEET

1. Match terms commonly used with grounds and jumpers to the correct definitions.

   - Jumper — Short piece of wire used to close an opening in a circuit
   - Terminal — Attachment on line equipment used to connect a conductor
   - Plating — Coating on terminal or connector to make it suitable for copper or aluminum conductors
   - Bi-metal — Two different metals fused together
   - Cold-flow — Movement of soft metal caused by expansion and contraction or pressure on a small area
   - Electrolytic corrosion — Destruction of aluminum conductor when moisture is present at the junction of two different kinds of metal

2. Match types of jumpers to their specific use. (Transparency 1)

   - Line jumper
     1. Connects line conductor at corners and double dead ends
     2. Connects line equipment to line conductor
   - Insulated jumper — Connects opening in line conductor while changes or repairs are being made
   - Grounding jumper
     1. Connects line neutral at corners and double dead ends
     2. Connects line equipment to neutral and pole ground

INFORMATION SHEET

3. State requirements for various jumpers.

   - Line jumper

     1. Must consist of similar material as the conductor being connected

     2. Must be the same size or ampacity as the conductor being connected

   - Insulated jumper — Must have insulation value greater than the voltage on which it is used

   - Grounding jumper

     1. Must be large enough to carry unwanted currents

     2. Must be bonded solidly to the conductor or equipment being grounded

4. Select from a list the line equipment that is connected by jumpers.

   - Transformer
   - Fuse cut-out
   - Lightning arrester
   - Capacitor

     (NOTE: Use a capacity tester before refusing. A capacitor can be bad even if not swollen.)

   - Voltage regulator
   - Oil circuit recloser
   - Sectionalizer
   - Line switch

5. Match types of jumpers to the correct installation methods. (Transparency 2)

   - Copper jumpers

     1. Install with copper or compression connector

     2. Install with slack to avoid vibration damage

     3. Install with bronze or plated connector

     4. Install with bi-metal or plated connector

INFORMATION SHEET

- Aluminum jumpers

  1. Install with large area or compression connector
  2. Install with bi-metal or plated connector
  3. Install with coating of inhibitor
  4. Install with slack to avoid vibration damage
  5. Install with copper ends when connecting to bronze or unplated terminals
  6. Install with aluminum connector

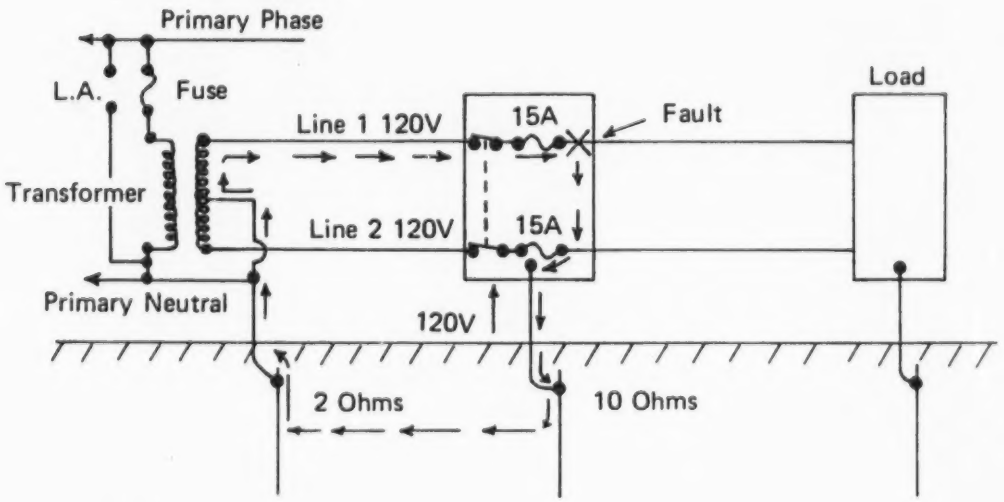
  (NOTE: Cold-flow occurs when aluminum conductor is installed with small area or set screw connectors. The problems of poor connections caused by cold-flow can be greatly reduced if large area or compression connectors are used with aluminum jumpers.)

6. State the requirements for safe grounding of line equipment.

   - All metal parts which are not used as energized conductors shall be grounded
   - All grounded parts shall be interconnected with a metallic conductor extending to the source

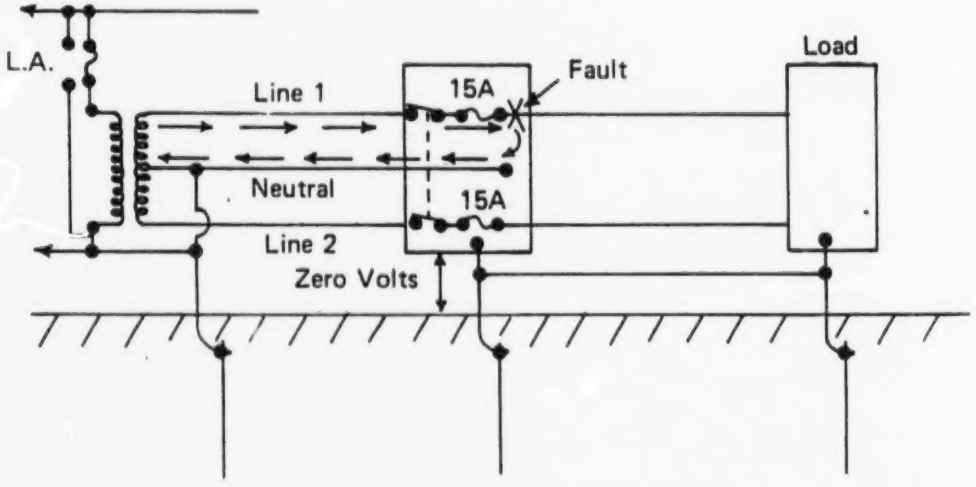
7. Distinguish between proper and improper grounding methods.

   - Improper secondary grounding

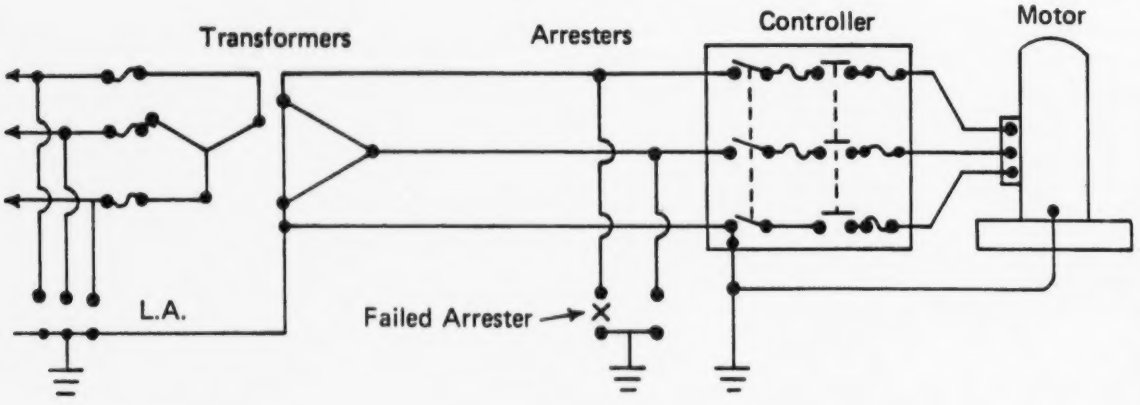


INFORMATION SHEET

- Proper secondary grounding



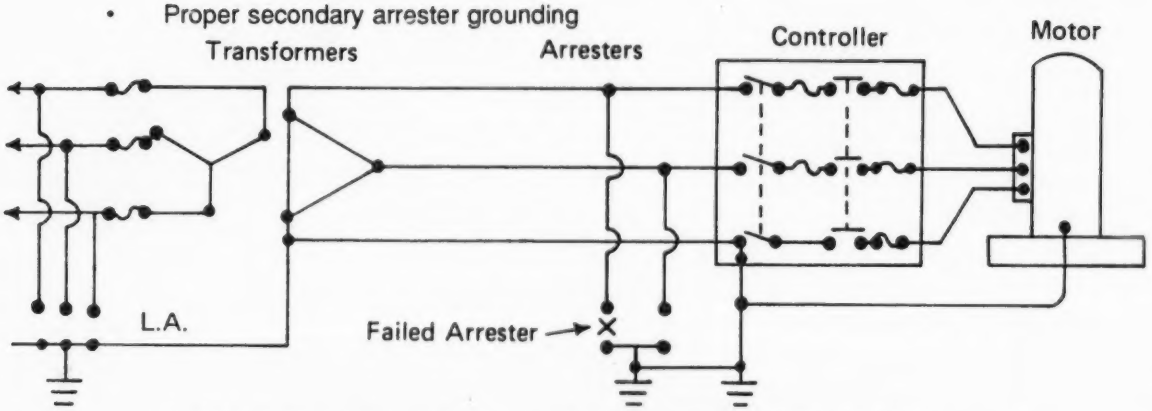

- Improper secondary arrester grounding




(NOTE: Failure of an arrester connected to an isolated ground can put lethal voltage on the arrester grounding conductor.)

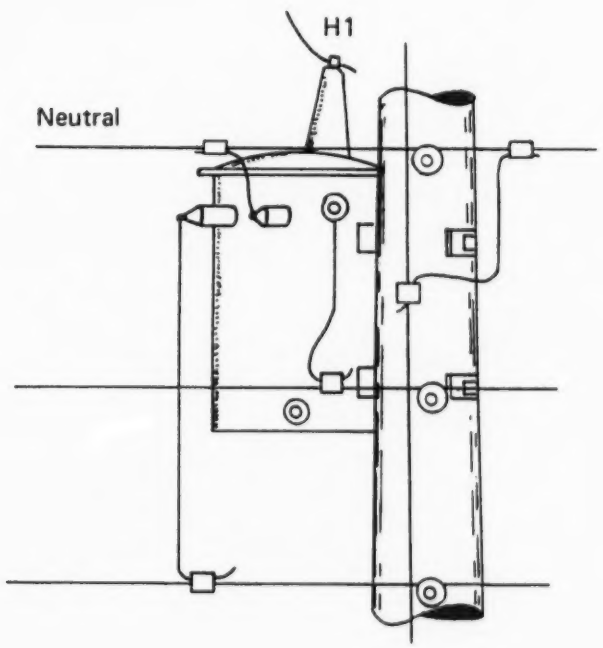
INFORMATION SHEET

- Proper secondary arrester grounding




(NOTE: With interconnected grounds the current flow will be high because the resistance is low. The high current flow will blow the transformer fuse.)

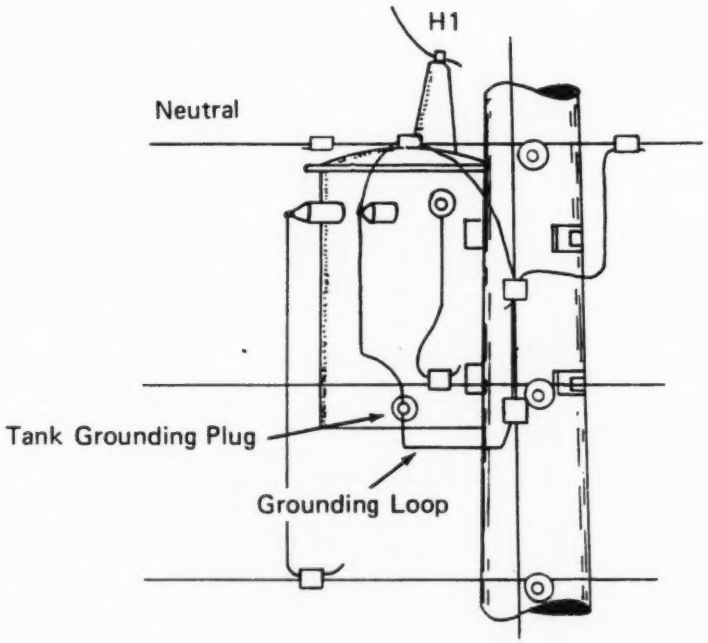
- Improper transformer grounding




(NOTE: The primary winding in a single bushing transformer is connected to the transformer tank. If the tank is not grounded, primary voltage will exist on the transformer tank.)

INFORMATION SHEET

- Proper transformer grounding



GROUNDS AND JUMPERS
(LINE EQUIPMENT)
UNIT 3

ASSIGNMENT SHEET 1

OBJECTIVE 8 — CALCULATE CURRENT FLOW OF FAULTED EQUIPMENT WHICH IS IMPROPERLY GROUNDED.

Calculate the current flow through faulted equipment when the voltage has been measured between the equipment and a solid ground and the resistance has been measured through the ground path of faulted equipment.

Current flow (amperes) = Voltage ÷ Resistance (ohms)

Example: Line voltage = 120 volts

Ground path resistance = 12 ohms

120 volts ÷ 12 ohms = 10 amperes (current flow)

(NOTE: Ten amperes flowing through a circuit that is fused at fifteen amperes will not blow the fuse. The current flow could continue indefinitely unless the load adds enough current to blow the fuse.)

1. Line voltage = 120 volts
   Ground path resistance = 12 ohms
   Current flow = _____

2. Line voltage = 240 volts
   Ground path resistance = 20 ohms
   Current flow = _____

3. Line voltage = 7200 volts
   Resistance to ground = 10 ohms
   Current flow = _____

4. Line voltage = 14,400 volts
   Resistance to ground = 80 ohms
   Current flow = _____

GROUNDS AND JUMPERS
(LINE EQUIPMENT)
UNIT 3

ASSIGNMENT SHEET 2

OBJECTIVE 9 — CALCULATE VOLTAGE ON IMPROPERLY GROUNDED FAULTED EQUIPMENT.

Calculate the voltage on faulted equipment when current flow and ground path resistance have been measured.

Voltage = Current flow (amperes) x Resistance (ohms)

Example: Current flow = 10 amperes

Ground path resistance = 12 ohms

10 amperes x 12 ohms = 120 volts

Voltage on equipment = 120 volts

1. Current flow = 5 amperes
   Ground path resistance = 20 ohms
   Volts on equipment = _____

2. Current flow = 20 amperes
   Ground path resistance = 10 ohms
   Volts on equipment = _____

3. Current flow = 8 amperes
   Ground path resistance = 20 ohms
   Volts on equipment = _____

4. Current flow = 12 amperes
   Ground path resistance = 40 ohms
   Volts on equipment = _____

# VOLTAGE AND CURRENT MEASURING
# UNIT 4

## UNIT OBJECTIVE

After completion of this unit, the student should be able to state the purposes of voltage and current measurements and be able to match currents and voltages to kVA ratings on service and primary lines. This knowledge will be evidenced by scoring 85 percent on the unit test.

## SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms commonly used with voltage and current measurements to the correct definitions.
2. State the purposes of voltage and current measurements.
3. Identify equipment used for voltage and current measurements.
4. State the correct procedure for determining voltage drop of a service.
5. State the correct procedure for determining current demand on a primary circuit in a specific area.
6. State procedures for determining current demand on a transformer.
7. List steps to obtain primary line voltage drop.
8. Select from a list reasons for current measurements.
9. Match full load secondary current at 240 volts single phase to the kVA ratings of a transformer.
10. Select from a list precautions to observe when making voltage and current measurements.

VOLTAGE AND CURRENT MEASURING
UNIT 4

INFORMATION SHEET

1. Match terms commonly used with voltage and current measurements to the correct definitions.

   - Indicating voltmeter — Voltmeter which gives instantaneous maximum and minimum readings

     (NOTE: Calibrate all instruments at regular intervals.)

   - Recording voltmeter — Voltmeter which records voltage and time readings on a tape or chart

   - Shop standard — Meter used to calibrate instruments used for actual testing

   - Voltage drop — Source output voltage minus the voltage at the end of the line

   - Voltage spread — Limit that service voltage varies from recommended base

   - Peak Load — Time during a day when maximum line current is flowing

   - Voltage levels — Minimum and maximum voltage from a 120-volt base

   - Power factor meter — Meter which indicates whether the line current leads or lags the voltage in electrical degrees

   - Ammeter — Meter which indicates current flow in amperes

2. State the purposes of voltage and current measurements.

   - Provide valuable information for the operation and development of an electrical system

   - Provide basic data for maintaining adequate voltage levels and current balance

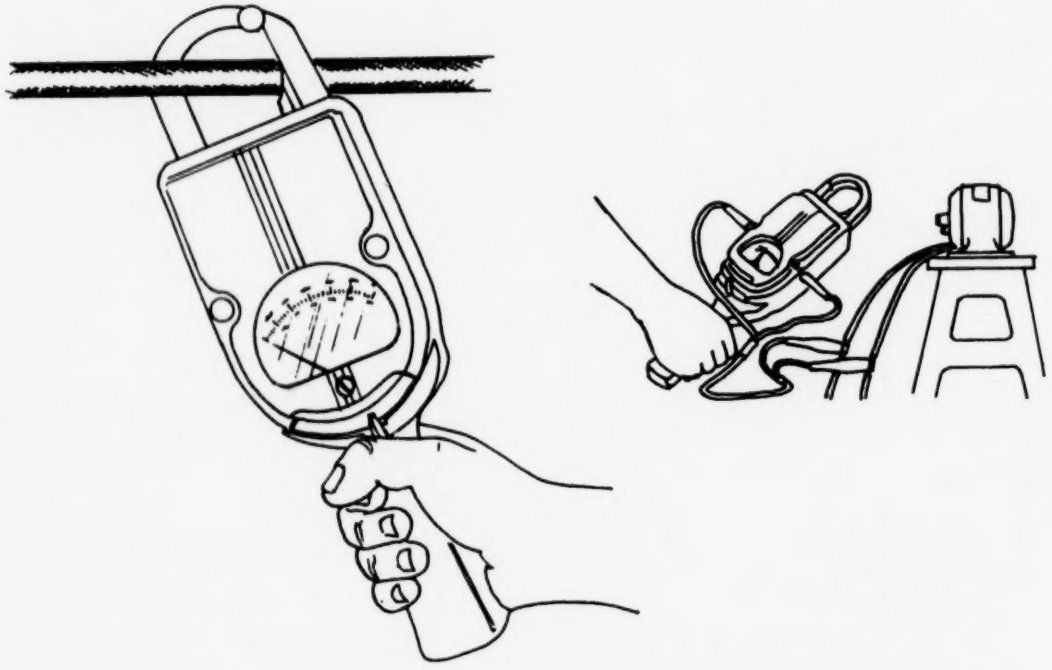
   - Calibrate all instruments at regular intervals

     (NOTE: Document the date and your action.)

INFORMATION SHEET

3. Identify equipment used for voltage and current measurements.

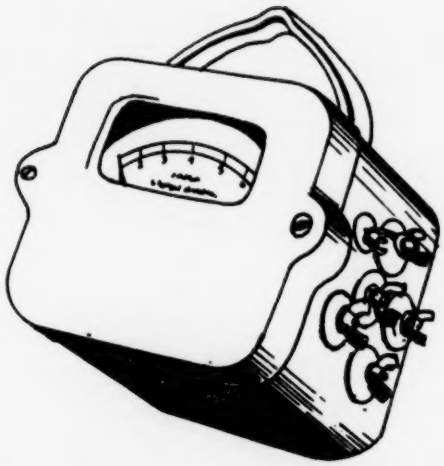
   - Clamp-on volt-ammeter



(NOTE: The clamp-on volt-ammeter may be used with an insulated stick attached to the handle to take ampere readings on primary voltage lines or to check amperes and voltage on low voltage circuits.)

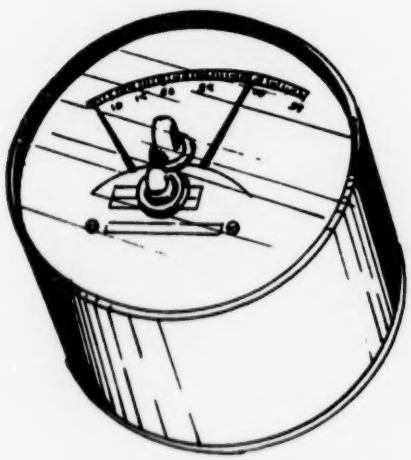
INFORMATION SHEET

- Primary line ammeter



(NOTE: This type of ammeter gives an instantaneous reading and indicates what the maximum line current has been. This type of meter replaces a jumper. It clamps onto the conductor without other connections.)

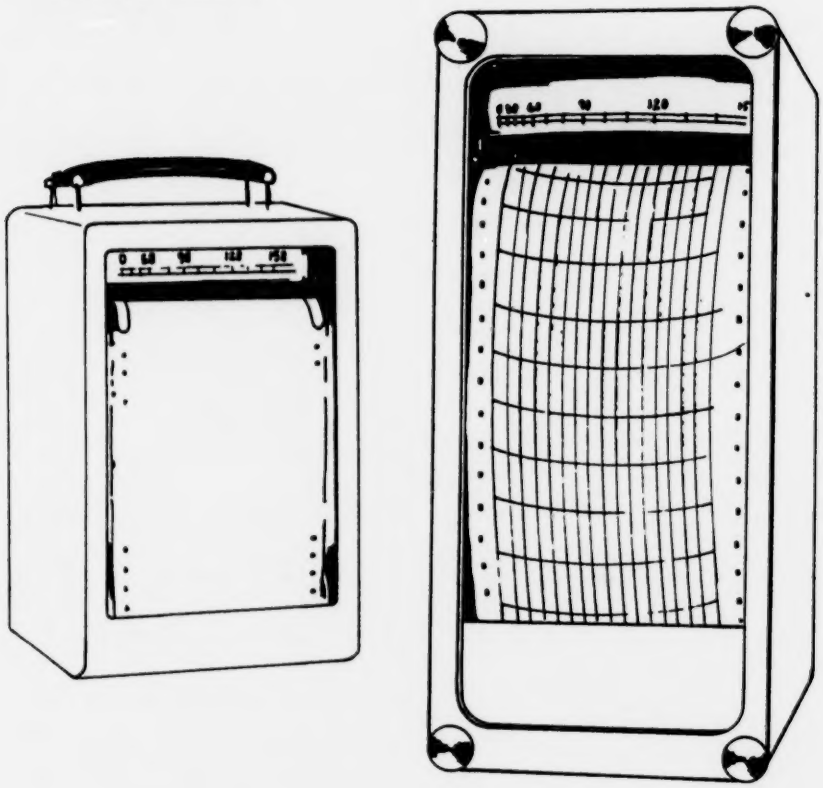
- Socket-type indicating ammeter



(NOTE: The socket-type ammeter may be placed in series with a kilowatt-hour meter to obtain maximum current requirements.)

INFORMATION SHEET

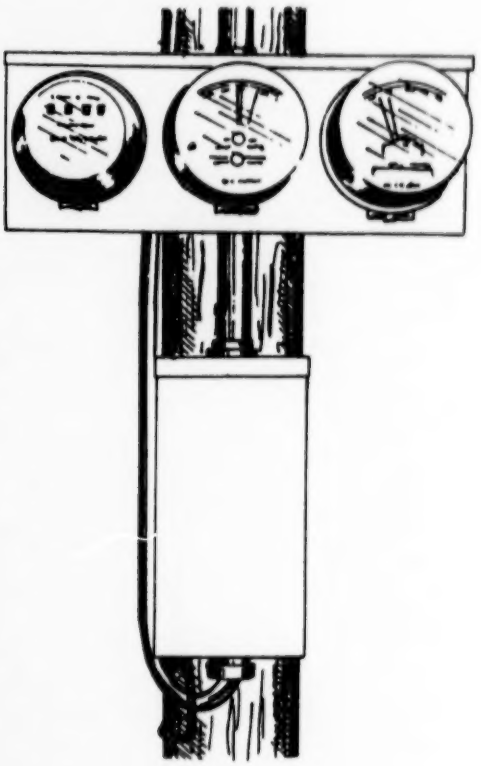
- Recording voltmeters



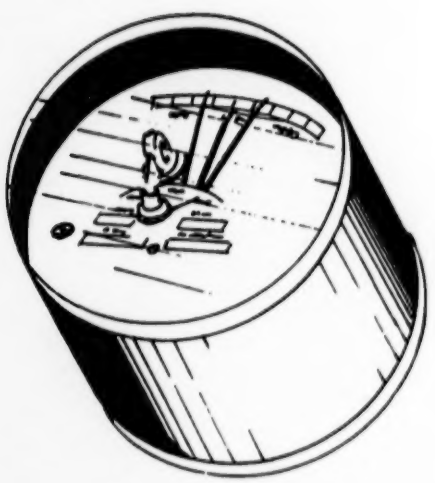
- Shop standard voltmeter

INFORMATION SHEET

- Kilowatt-hour, volt, and ammeter test block

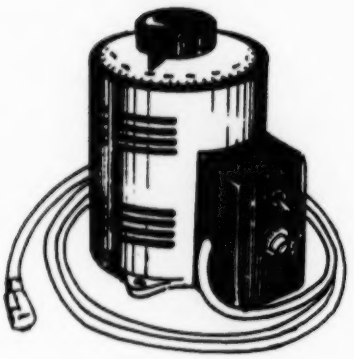


- Socket-type voltmeter



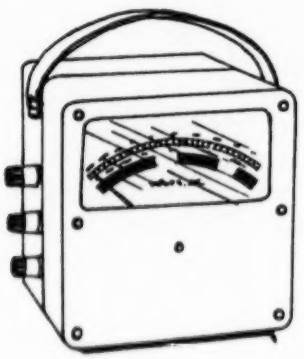
INFORMATION SHEET

- Variable voltage source



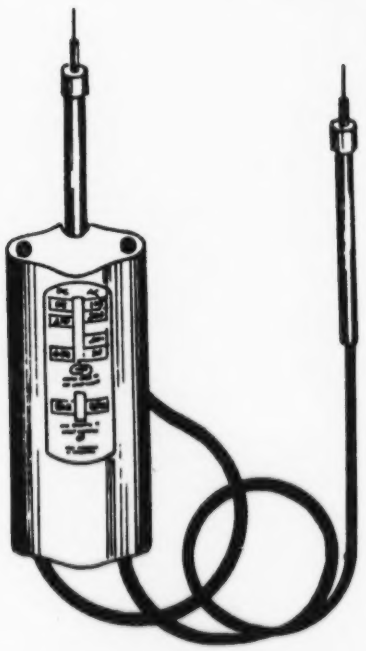
(NOTE: Calibration of a voltmeter may be done with greater accuracy when different voltage levels are used to check meters.)

- Voltmeter



INFORMATION SHEET

- Voltage tester



(NOTE: The voltage tester checks approximate potential and is not suitable for an accurate check of voltage.)

4. State the correct procedure for determining voltage drop of a service.

   - Check voltage at source (transformer)
   - Check voltage at delivery point (meter)
   - Subtract delivery point reading from source reading

   (NOTE: Voltage readings should be made simultaneously at the source and delivery point with meters that have been calibrated.)

5. State the correct procedure for determining current demand on a primary circuit in a specific area.

   - Install three clamp-on type indicating ammeters on one circuit at substation
   - Install three clamp-on type indicating ammeters on the same circuit a few miles from substation

   (NOTE: The indicating ammeters should be left on the line during an extremely hot or extremely cold period to obtain an accurate demand. The difference in readings of the two sets of meters will show current demand in the area between the two sets of meters.)

INFORMATION SHEET

6. State procedures for determining current demand on a transformer.

   - Read demand on demand meter and multiply by meter multiplier to obtain kW demand
   - Install indicating ammeter on secondary side of transformer

7. List steps to obtain primary line voltage drop.

   - Install recording voltmeter at the substation

     (NOTE: The recording voltmeter may be connected to potential leads at the substation meter.)

   - Install recording voltmeter at or near the end of the primary line

     (NOTE: The recording voltmeter set near the end of the line should be connected to a transformer which is not in use or connected to a potential transformer installed for the purpose of obtaining an accurate voltage reading.)

   - Subtract the voltage at the end of the primary line from the substation voltage

     (NOTE: The time markings on the tape or chart of each recording voltmeter should be set to the correct time to get an accurate comparison of the two voltage readings.)

8. Select from a list reasons for current measurements.

   - Substation ampere demand
   - Phase balance of each circuit
   - Individual circuit demand
   - Oil circuit recloser loading
   - Substation transformer and regulator loading
   - Voltage-regulator line drop compensation settings
   - Measurement of transformer loading

INFORMATION SHEET

9. Match full load secondary current at 240 volts single phase to the kVA ratings of a transformer.

| kVA Rating | Current |
|---|---|
| 3 kVA | 12.50 amperes |
| 5 kVA | 20.83 amperes |
| 10 kVA | 41.67 amperes |
| 15 kVA | 62.50 amperes |
| 25 kVA | 104.17 amperes |
| 37.5 kVA | 156.25 amperes |
| 50 kVA | 208.33 amperes |
| 75 kVA | 312.50 amperes |
| 100 kVA | 416.67 amperes |

10. Select from a list precautions to observe when making voltage and current measurements.

- Wear your protective equipment always
- Set voltmeter on highest scale before applying to voltage
- Attach ammeter in series with line, never in parallel
- Do not install ammeters on a primary line by hand; always use a hot stick
- Do not leave exposed energized connections when setting a recording meter
- Transport and handle all instruments carefully
- Set ammeter on high scale before checking amperage

# A CIMC "RAINBOW PROGRAM"

# FOR STANDARDS OF TEACHING EXCELLENCE

## STUDENT'S PROMISE

One very important factor contributing to higher student performance is the expectation of parents and teachers. Experience suggests that teachers and parents who expect student success find that students perform better, attend class more regularly, have positive attitudes, and stay in school longer. The students' success and confidence in their ability to learn may cause additional growth and behaviors that exert a positive influence throughout life.

***Let it be publicly known that students in this program have high expectations.***

I recognize that America's future is dependent on my success in school.
I will attend school regularly.
I will keep regular study hours at home.
I will read each day at home.
I will never accept failure.
I will accept responsibility for my school challenges.
I will respect the rights and feelings of others at home, school, and work.
I will develop positive qualities in myself that my friends will admire.
If I have difficulty, I will insist on help with my school work.
If I have difficulty, I will always try harder.
I will ask my teacher for clear learning objectives.
I will practice good citizenship skills at home, school, and work.
I will keep my parents/guardians informed daily about my school activities.
I will develop goals for school, home, and work.
I will seek advice from my teachers, parents/guardians, and counselors on career guidance.
I will constantly practice the skills of a good student.

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